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WASHINGTON, D. C.

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TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION SIXTH ANNUAL MEETING, APRIL 30-MAY 1. 1925,[1] WASHINGTON, D. C.

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GENERAL

STATUTES AND BY-LAWS OF THE AMERICAN GEOPHYSICAL UNION

(As amended to May, 1925)

PREAMBLE

The American Geophysical Union is hereby established by the National Research Council. It supersedes the "American Section of the proposed International Geophysical Union." The American Geophysical Union is the American National Committee of the International Geodetic and Geophysical Union and the Executive Committee of the American Geophysical Union is the Committee on Geophysics of the National Research Council. The American Geophysical Union is constituted as follows:

ARTICLE 1

Objects

(a) To assist in carrying out the objects of the International Geodetic and Geophysical Union, which are: To promote the study of problems concerned with the figure and physics of the Earth; to initiate and co-ordinate researches which depend upon international co-operation, and to provide for their scientific discussion and publication; and to facilitate special researches, such as the comparison of instruments used in different countries.

(b) To promote and co-ordinate the study of the various branches of geodesy and geophysics in the United States of America and its outlying territories.

ARTICLE 2

Membership

The membership of the American Geophysical Union shall be as follows:

(a) Those who composed the membership of the "American Section of the proposed International Geophysical Union" on July 1, 1919.

(b) Those who may be appointed by the Executive Board of the National Research Council upon nominations submitted by the Executive Committee of the American Geophysical Union.

(c) The Chairman of the Division of Foreign Relations, the Chairman of the Division of Physical Sciences, the Chairman of the Division of Chemistry and Chemical Technology, the Chairman of the Division of Geology and Geography, and the Chairman of the Division of Biology and Agriculture, of the National Research Council, members *ex officio*.

(d) The American officers of the International Geodetic and Geophysical Union and of its Sections, members *ex officio*.

ARTICLE 3

Sections

The American Geophysical Union shall be divided into Sections, in accordance with the organization of the International Geodetic and Geophysical Union, as follows: (a) Geodesy; (b) Seismology; (c) Meteorology; (d) Terrestrial Magnetism and Electricity; (e) Oceanography; and (f) Volcanology.

The members shall designate the Section, or Sections, to which they will belong. The *functions of the Sections*, in their respective fields, shall be the promotion of the objects of the American Geophysical Union.

ARTICLE 4

Officers of the American Geophysical Union

The *Officers of the American Geophysical Union* shall consist of a chairman and a vice-chairman, elected to serve for a period of three years, and not to be eligible for immediate re-election to their respective offices; and a general secretary, to serve for a period of three years.

ARTICLE 5

Officers of Sections

The *Officers of the Sections* of the American Geophysical Union shall consist for each Section of a chairman, a vice-chairman, and a secretary, whose periods of office shall correspond to those of the Union. The Chairman of each Section shall have the power to appoint, with the right to vote, a representative of the Section to such meetings of the Executive Committee of the Union as he may be unable to attend.

ARTICLE 6

Executive Committee

The *Executive Committee* shall consist of the chairman, the vice-chairman, and the general secretary of the American Geophysical Union, and of one representative from each of the sections of the Union, who shall be the chairman thereof or a member appointed by him; and, in addition, *ex officio*, the American officers of the International Geodetic and Geophysical Union, and of its Sections, the chairman of each of the Standing Committees of the American Geophysical Union, and the chairman of each of the following Divisions of the National Research Council: Foreign Relations, Physical Sciences, Chemistry and Chemical Technology, Geology and Geography, and Biology and Agriculture. This Committee shall have charge of all administrative matters of the American Geophysical Union, and shall be the representative of the Union in its relations with the National Research Council and with the International Geodetic and Geophysical Union. The Executive Committee, in consultation with the Sections, shall nominate to the Executive Board of the National Research Council delegates, or representatives, to the meetings of the International Geodetic and Geophysical Union and of its Sections, in accordance with the regulations fixed by the International Research Council for the voting power of the United States of America.

ARTICLE 7

Annual Meetings

The American Geophysical Union and its Sections shall meet annually at such time and place as may be chosen by the Executive Committee of the Union. The officers of the Union and of the Sections shall be elected at this annual meeting.

ARTICLE 8

Special Meetings

Special Meetings of the American Geophysical Union, or of its Sections, may be called when necessary by the respective chairmen.

ARTICLE 9

By-Laws

The American Geophysical Union is authorized to enact such by-laws as may be necessary for the performance of its functions and duties.

ARTICLE 10

Amendments

Amendments to the Statutes of the American Geophysical Union shall be subject to the approval of the National Research Council.

BY-LAWS

The fiscal year of the American Geophysical Union shall conform to the fiscal year of the National Research Council.

Standing committees on Statutes and By-Laws, on Membership, on Meetings, and on Budget, shall be appointed for the ensuing fiscal year by the Chairmen-elect of the Union prior to the beginning of each year.

All committees of the American Geophysical Union shall terminate at the end of the fiscal year for which they may be appointed.

Meetings of the Union shall be called at least thirty days in advance, and those present at the meeting shall constitute a quorum.

Meetings of the Executive Committee shall be called by the Chairman, and those present shall constitute a quorum.

Final action shall not be taken by the Executive Committee on matters affecting any Section in the absence of the Chairman of such Section, or his representative.

No mail ballot shall be closed until at least thirty days after the date of issue.

After thirty days' notice has been given, amendments to the Statutes (all of which are subject to the approval of the National Research Council) may be voted on either by mail or at a regular meeting of the Union.

Amendments to the By-Laws may be proposed either by mail or at a regular meeting; when voted on by mail they require for adoption a majority vote of the members; when voted on at a regular meeting they require for adoption a three-fourths vote of the members present.

Any amendment to the Statutes or By-Laws proposed by at least five mem-

bers shall be submitted for vote to the members of the Union by the Executive Committee.

A member of the American Geophysical Union may be dropped from the Union by a three-fourths vote of the members of the Executive Committee.

Statutes and By-Laws adopted by a Section shall not conflict with the provisions of the Statutes and By-Laws of the Union.

Matters pertaining to a Section or Sections, and not pertaining to the Union as a whole, shall be acted upon by the Section or Sections concerned.

REPORT OF THE MEETING OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION AND ITS SECTIONS HELD AT MADRID, OCTOBER 1-10, 1924. PREPARED BY THE DELEGATES FROM THE UNITED STATES

THE SECOND GENERAL ASSEMBLY OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION

HARRY FIELDING REID, *Chairman of the Delegation from the United States*

The second general assembly of the Union took place in Madrid, beginning October 1, 1924, in the building of the National Parliament. The king of Spain presided at the first meeting and the proceedings consisted of addresses of welcome. Then for a week the several sections met in different rooms and discussed matters of special interest to themselves. There are now thirty nations adhering to the Union, and nearly all were represented by delegates or by proxy. The United States had but four delegates, which made it impossible to keep in close touch with the discussions of the seven sections. At the final meeting on October 8 the several sections reported the results of their conferences to the general assembly.

The section of geodesy adopted the Hayford spheroid as the spheroid of reference for geodetic work, and it is hoped that it will be accepted by all nations. If all locations are referred to the same spheroid it will help greatly in connecting up the triangulations of the different countries. The principle of isostasy was discussed and accepted, and its application will improve the accuracy of the triangulations. The reduction of observations in accordance with this principle will probably be carried out in Washington. It was decided to make determinations of relative gravity between the base stations of the several countries so that the relative gravity at all stations may be properly compared. This is of great value for the determination of the figure of the earth and for studies of isostasy. A world-net of longitudes is to be determined by radio; by carrying this net completely around the world systematic errors can be largely eliminated, and longitudes more accurately fixed. By repetition at a future date, any east-west movements of the continents can be measured. North-south movements can be determined from the observations at the latitude variation stations, three of which continued their observations throughout the war; the section of geodesy will assist, by appropriations in the reduction of these observations. Dr. F. A. V. Meinesz, of Holland, described a method of determining gravity at sea, by swinging pendulums in a submarine, sunk some thirty meters below the sea surface. The results of some observations in the Indian Ocean were very accordant and indicate a very close approach to isostatic equilibrium in that region.

In the seismological section, the question of publishing annual lists of earthquakes was discussed, and it was decided, largely on account of lack

of funds, not to undertake this for the present; but Professor Turner will continue to issue the International Summary, which contains the records and locations of the more important shocks. It was decided that the transmission curve, which gives the time of transmission of earthquake waves from the origin to distant points, requires more study before an official curve could be adopted. Reports were made on the transmission of disturbances due to explosions, which travel more slowly than is indicated by the general transmission curve, due undoubtedly to the fact that they travel through the superficial part of the earth's crust. Reports were made on seismological work in Spain, which is being developed with much vigor; and on the work of the Carnegie Institution in California. The fault map of California and the diagrams of Anderson's new seismograph aroused much interest; also the account of De Quervain's large instrument which has been mounted at Zurich, and is giving satisfactory records of small shocks in the Alps. These instruments present a strong contrast; the former weighs a fraction of a gram, the latter twenty-one tons. The Japanese delegates gave interesting accounts of the great earthquake of 1923 before both the section of seismology and the section of geodesy. The Central Bureau announced that it would begin the publication of seismological memoirs. The committee on the troublesome subject of microseisms was continued.

The most important question discussed in the meteorological section was the project of compiling weather charts of the northern hemisphere for the third quarter of 1923. This is an important matter and could best be carried out by an international weather bureau. Some doubts were expressed as to the propriety of "placing money at the disposal of an existing state service for carrying on work of an international character in conjunction with a commission." Many other interesting questions were discussed: sampling air at great heights; measurement of relative brightness of ground and cloud; determination of the variations of the hydrogen content of the air; spectral measurements of solar radiation intensity, at Izana, Canary Isles; daily observations of temperature and pressure in the free air; observations of air-borne parasites; stations in mountainous districts and in the South Pacific, etc. The section recommended to the General Assembly the appointment of a committee to consider a simplification of the Gregorian calendar, and the recommendation was accepted.

In the section of terrestrial magnetism and atmospheric electricity, reports were made of work accomplished in various countries. The section highly commended the work of the Carnegie Institution in the determination of the magnetic elements all over the world. It called attention to the importance of magnetic and electric observations in high latitudes, and recommended the west coast of Greenland, and Jan Mayen

Island or Spitzbergen, as suitable locations for observations. Magnetic data from high latitudes in years near sunspot maxima are very desirable. Observations to reduce atmospheric potential gradients to volts per meter over level ground are much needed. It is also most important to investigate the magnetic properties of rocks from all over the earth, and from different geological ages. An instrument to measure the vertical intensity of the earth's magnetic field in absolute measure is much to be desired.

The American proposal to approve explorations of the oceans was adopted by the section of oceanography and by the general assembly. Biological oceanographers have been admitted to this section.

The committee on glaciers, which was appointed by the International Geological Congress, has lapsed since the beginning of the war. The section of hydrology of the Union wishes to take up the problems of the variations of glaciers, and the Union made a small appropriation to enable Professor Mercanton, of Switzerland, to consult with members of this section and devise some means of continuing the records.

None of the American delegates was able to attend the meetings of the sections of volcanology, oceanography, or hydrology. This emphasizes the importance of making provision for at least one American delegate to each section at future meetings of the Union.

The arrangements for the entertainment of the delegates and their families were most elaborate. The king and queen of Spain received them at the royal palace; and the mayor of Madrid held a reception at the mayoralty. The reception committee (Sen. D. L. Cubillo, Chairman, Sen. D. J. Galbis, Secretary) were indefatigable in their efforts. Excursions were made to the most interesting places in the neighborhood of Madrid, including the city of Toledo, all at the expense of the committee; a concert was given at the opera house, the bull ring and the museums were thrown open; and the meetings closed with a banquet at the Hotel Ritz. I do not think such lavish hospitality could have been tendered in any other city of the world. After the meetings, excursions were arranged to the cities of southern Spain and to the eastern coast; everywhere the hospitality was most generous.

The next general assembly of the Union will be held at Prague in 1927.

The Johns Hopkins University,
Baltimore, Maryland.

REPORT ON THE MADRID MEETING OF THE SECTION OF GEODESY, INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION

WILLIAM BOWIE, *Delegate*

Early in 1924 it was realized by the Executive Committee of the Section that the agenda for the Madrid meeting would be a very heavy one. As is well known, the geodetic work that is considered by the Section consists of a number of branches; among them may be enumerated—astronomic longitudes, latitudes and azimuths; measurement of base lines; triangulation of various degrees of precision; traverse, precise leveling, gravimetric surveys, mean sea level, which furnishes starting points for leveling; variation of latitude; projections; figure of the earth; the theory of isostasy; and trigonometric leveling.

Each of the foregoing subjects should be considered at an international conference, for it is only by securing the active co-operation of geodesists in the various countries that the best results can be obtained.

Under the circumstances, the meeting of the Section of Geodesy was called for on September 26, 1924, although the formal opening of the meeting of the Union as a whole was called for October 1. Two days prior to the meeting of the Section, the Executive Committee held a number of sessions to make the final plans for the meeting of the Section and to consider some matters of a technical nature which had been referred to the Committee by the meeting of the Section held at Rome in 1922. The Executive Committee perfected the organization for the Madrid meeting and made preliminary lists of Committees with their provisional membership, which committees were to handle the various items included in the Agenda. When the Section met on the 26th the fifteen committees were appointed and immediately the work of the Section was undertaken. It is unnecessary to go into the details of the proceedings of the various sessions, for they will be given in the report which will be issued by the Secretary of the Section of Geodesy.

I feel it appropriate, however, to make some general remarks on the desirable character of subjects which should come before an international scientific assembly. As is well known, the geodesists of the world organized an international association many years ago and the Section of Geodesy of the International Geodetic and Geophysical Union is working along somewhat the same lines as the old association. It is felt that there should come before the International Union only those questions upon which international agreement, co-operation or expression of opinion is desired. These are surely the purposes for which the conferences are called. There is no place or time for purely scientific papers of a detailed nature. Such matters require a great deal of time for

presentation and, owing to the fact that not all the delegates know any common language well enough to follow a detailed oral presentation, the results of scientific accomplishments or descriptions of methods should be given in abstracts only, in what may be called national reports. Such national reports, which have always been a feature of international geodetic conferences, cover the work accomplished in each of the adhering countries during the interval since the previous conference.

In addition to the national reports, reporters for each of the branches of geodetic science cover in a general way their field, showing its present status and recent accomplishments. The national reports and the statements of the special reporters are almost invariably printed, or multigraphed, and distributed to the members present at the meeting. The presentation of these national reports and statements by the special reporters is almost invariably in abstract.

There is no question but that countries profit by having representatives to scientific meetings of an international character but it should be realized that, at such a convention as that of the International Geodetic and Geophysical Union, one representative can keep in touch with the work of a single section only. Many hours each day are given to the sessions of a section and, in addition, the delegate may be on several committees, and is sure to be on at least one. This means that the delegate has no time to attend the meetings of sections other than the one to which he may be accredited. Unfortunately, at Madrid there were only four official delegates from the United States; this meant that three Sections had to be neglected. It is hoped that at future meetings of the Union there will be at least one official representative from the United States to each of the Sections and to some of the Sections there should be two or more delegates.

Among the outstanding accomplishments of the Madrid meeting were the adoption of the Hayford spheroid, for use in triangulation computations in those countries which have not yet adopted a spheroid, or for those countries which, having adopted a spheroid in the past, wish to change to one which is nearer the truth. This spheroid will also be used for all scientific investigations. Plans were made for the extension of a net of longitude stations around the world, in co-operation with astronomic observatories. The transmission of signals for the comparison of the time-pieces at contiguous stations will be by radio. This longitude work will provide national base stations for longitude and will provide a means for checking the stability of the positions of continents and islands with reference to each other. Provision was made for continuing studies in the variation of latitude and for computation, reduction and publication of the results of the observations for the variation of latitude

made during and just after the war. Preliminary plans were made to strengthen the network of national gravity base stations.

The National Committee for Geophysics of Spain is to be commended in the highest terms for its efforts in making perfect the arrangements for the meeting of the Union and its Sections. Not a single item that could add to the convenience or the comfort of the delegates was overlooked. The entertainments and excursions provided for were most delightful and did not materially interfere in any way with the serious work of the conference, except for the one day when the delegates were taken on special train to that most interesting city, Toledo. This break in the meetings of the Union furnished a splendid means for the delegates to become acquainted with each other, in as much as the trip to Toledo occurred very shortly after the beginning of the conference. Personal contact is most valuable at such a gathering in order to facilitate the proceedings.

The conference was honored by the presence of His Majesty the King at the opening meeting of the Union, at which he presided. As far as was known to the delegates present, this is the only occasion at an international scientific conference where the ruler of the country took so active a part in the proceedings. We all felt that this was an unparalleled tribute to science and to scientific workers.

There were present at the meetings of the Section of Geodesy fifty-six delegates and twenty-three guests, representing twenty-six countries.

The members of the Section felt that the results accomplished made the Madrid meeting the most productive one that had ever been held, even including the meetings of the old International Geodetic Association.

U. S. Coast and Geodetic Survey,
Washington, D. C.

REPORT OF THE MADRID MEETINGS OF THE INTERNATIONAL SECTION OF METEOROLOGY, INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

HERBERT H. KIMBALL, *Delegate*

Delegates to the Madrid Meetings of the International Union of Geodesy and Geophysics in October, 1924, will cherish the memory of the deep blue skies, the crisp, invigorating October atmosphere, and, above all, the hearty and open-handed hospitality of Spain. While especial mention should be made of Senors Cubello and Galbis of the Madrid committee for their efforts in our behalf, it was, after all, the Spanish nation, headed by their majesties the King and the Queen, and assisted by their ministers, that really gave to the meetings their setting of artistic beauty. It was refreshing as well as a relaxation to pass from

the tenseness of a scientific conference to a reception in the Royal Palace, a concert in the Royal Theater, a banquet *à la Madrid*, or an excursion to a suburban restaurant, an art museum, a scientific observatory, or, for some of the delegates at least, even a bull fight.

The memory of these various delights forms the artistic background for our mind's picture of the scientific conferences, which engaged our days in Madrid, and about which I am now to speak to you, confining myself to the meetings of the Meteorological Section.

The agenda for the meetings, which had been made up from items proposed by the national committees of the adhering countries, covered a wide range of subjects. Sir Napier Shaw, President of the Section, before he left London spent many busy days in classifying these items, and assigning them to their proper place on the program. Then, after reaching Madrid, he had other proposed items handed to him by the delegates, upsetting his program, and making difficult the adequate consideration of important items already proposed.

Since items presented too late to be circulated among the adhering countries can only have a place on the agenda by unanimous consent, I think it would be well to inform the Bureau of Section C of the International Union that your delegate to the next conference will be instructed to withhold his consent to the consideration of these belated items.

The final action on the different items considered is expressed in twenty-seven resolutions that were adopted by the Section. These have already been published in full in the Monthly Weather Review for November, 1924, Vol. 52, pp. 533–536, and will be published later in the Proceedings of the Section. A brief summary follows.

Four resolutions refer questions to other organizations for consideration. Twelve others make recommendations or express an opinion, but do not contemplate action by the section. The remaining eleven resolutions call for action on the part of the section or of some of the national committtees, as follows:

1. The preparation of a card index of names for the regular distribution of the proceedings and the distribution of notices of prospective meetings.

2. Details of a plan for obtaining samples of air from great heights. (Assigned to the National Committee of the United States.) Fifty pounds may be appropriated for the observations at the discretion of the executive committee of the Section.

3. The appointment of a commission with a grant of £400, to purchase self-recording pyrheliometers for use in Northern Canada, Spitzbergen, New Zealand or Samoa, Amazon valley of Brazil or Belgian Congo, and Argentine for South Orkneys, and also for the purchase of instruments

of Mr. Richardson's design for measuring the relative brightness of ground and cloud surfaces from airplanes, in the four countries having airplanes at their disposal, namely, France, Great Britain, Italy, The United States.

4. An illustrative application of the principles employed in each country for forecasting the weather. September 25, 1923 (forecast for the 26th) was selected as the day on which the application of the principles was to be illustrated.

5. Continuation of efforts to obtain pilot and sounding balloon observations over the sea and special regions over the land. The sum of £750 was placed at the disposal of the Bureau of the Section for this work, provided that £500 of this amount may be applied towards the publication of a year's results of observations of the upper air.

6. The international days of the Commission for the study of the upper air should be included in the days selected for the observations of atmospheric dust.

7. The appointment of a commission to arrange and advise concerning further investigation of atmospheric dust, including the relation between dust and visibility and also the potential gradient of atmospheric electricity.

8. An invitation to those who are interested, to circulate a calendar for the year 1925 showing how they would desire meteorological observations to be dealt with.

9. Finally, the Section decides to make, as an example, and on a precisely limited subject, a test of the services which would be rendered by an International Meteorological Bureau, the organization of which is now being studied by a commission of the International Meteorological Committee.

The problem to be solved, chosen from those which clearly involve international collaboration, is the following: The compilation of an atlas, or of bi-daily charts, covering the greatest possible part of the Northern Hemisphere, for the third quarter of the year 1923. M. La Cour, President of the North Atlantic Chart Commission, will have charge of the execution of the work. He will work under the instruction of a commission including members of the Union belonging to the above commission of the International Committee. A sum of £500 will be allotted for the work.

This last resolution was adopted in the face of considerable opposition, as it was considered unwise by some to "place money at the disposal of an existing state service for carrying on work of an international character in conjunction with a commission."

U. S. Weather Bureau,
Washington, D. C.

REPORT OF MADRID MEETING OF INTERNATIONAL SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY, OCTOBER, 1924

LOUIS A. BAUER, *Delegate*

Bulletin No. 4 of the Section of Terrestrial Magnetism and Electricity of the International Geodetic and Geophysical Union, consisting of ten pages and devoted to a General Report of the Madrid Meeting of the Section, was issued last December, by the writer, who was re-elected Secretary and Director of the Central Bureau of the International Section for the period 1924-1930. As a copy of this Bulletin has already been sent to each member of the Amerian Section, it will not be necessary to go into further detail here.

It will be of interest, however, to report that arrangements are already under way towards putting into effect some of the twenty-two resolutions which were passed at the Madrid meeting. Thus, word has been received from Dr. D. la Cour, director of the Danish Meteorological Institute, that, in accordance with Resolution No. 8, a permanent observatory will be established this coming summer at Godhavn, just south of Disco, on the west coast of Greenland. There are also indications that, following Resolution No. 10, the Canadian Government before long will fully equip the Meanook Magnetic Observatory; at the present time only photographic records of the variations of the magnetic declination are being obtained at this observatory, nearest of any to the North Magnetic Pole.

Information has also been received with regard to the prosecution of the magnetic survey of the Baltic Area (Resolution No. 21) and the magnetic survey of Norway.

The Apia Observatory, following the hope expressed in Resolution No. 13, is maintaining its full activity in terrestrial magnetism, atmospheric electricity, seismology, meteorology, etc., under the joint auspices of the New Zealand Government, the British Admiralty and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

Preliminary information is being collected by Prof. A. Tanakadate, as reporter, on the best means of accurately observing time of commencements of abrupt-magnetic disturbances (See Resolution 2*d*.). The Department of Terrestrial Magnetism of the Carnegie Institution of Washington and the United States Coast and Geodetic Survey have co-operatively investigated some recent cases of abrupt-magnetic disturbances, as recorded at eight magnetic observatories of the two respective organizations. The range in magnetic latitude of these observatories is from 46°.3 S to 82° N, and the data indicate that, on the average, it would take an abrupt disturbance from two to three minutes to progress from

the magnetic equator to the magnetic poles; the correlation factor is on the order of 0.9 for the abrupt disturbances in the intensity of the Earth's magnetic field.

Renewed interest, following the recommendation expressed in Resolution No. 16, is being shown in upper air investigations pertaining to terrestrial magnetism, atmospheric electricity, and radiotelegraphy.

Since the Madrid meeting, word has been received that the Geophysical Commission of Norway has decided to take the necessary steps for joining the entire International Geodetic and Geophysical Union; heretofore, Norway had merely been an adherent to the International Section of Geodesy. Information is likewise at hand that other countries will soon join the Union, so that most likely by the time of the next meeting, to be held at Prague in 1927, the chief countries the world over will be adherents.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C.

THE MADRID MEETING OF THE SECTION OF OCEANOGRAPHY, INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION

N. H. Heck

Eight countries were represented and two, Canada and the United States, sent reports. Prof. Odon de Buen of Spain was elected president of the Section in place of the Prince of Monaco, deceased, Dr. Magrini continuing as Secretary.

Secretary's Report.—The Secretary's report brings out the fact that with the suppression of the sub-section of Oceanography of the International Union of Biology which was established at Brussels, the name of the Section was changed from Section of Physical Oceanography to Section of Oceanography, to include both fields.

The function of the Section in co-ordinating the work of various commissions, such as that for the Atlantic and that for the Pacific, is of great importance. These commissions consist of government officials of countries interested, the commissions serving to co-ordinate the work, but with the individual nations preserving full autonomy.

Activities of the Section include:

1. Establishing of central library and catalogue. Good progress is being made but more contributions are needed. They are filed by authors, by subjects and by regions.

2. Publishing of bibliographical bulletin. This is making good progress. Authors are requested to use a special form in reporting their publications to insure uniformity.

3. List of oceanographers. The first list has been prepared and is being distributed for correction. Each subsequent list is expected to be more complete.

4. Publication of international vocabulary of oceanography. Co-operation of the International Hydrographic Bureau is being secured.

5. Publication of international manual for observations to be made at sea. A proposal made at Rome was modified so that this would be published in three volumes containing respectively: I. Hydrography, Morphology and Lithology. II. Meteorology and Physics. III. Chemistry and Biology. A difficulty was encountered in that this work must go hand in hand with the international vocabulary of oceanography in order to insure uniformity of expression.

6. Exchange of publications was considered and its importance emphasized.

Reports of Commissions.—Commission of the Atlantic. Reports primarily on the existing organization, explain the part carried on by different nations and lack of co-ordination of certain parts of the work. A recommendation was made that secretaries of four existing organizations (two in Europe, one in North America, and one in Africa) join with a fifth to be selected for Latin America, to co-operate with the General Secretary in co-ordinating the work.

Commission of the Pacific. Reported by letter from the President, Dr. Littlehales. Lack of American co-operation is hindering co-operation of nations bordering on the Pacific. Proposed American Naval Expedition may remedy this. Present task is to co-ordinate work of Pan Pacific Scientific Congress and various branches of the National Research Council. Acceptance of delegation on commission by representatives of all nations concerned is promising of effective organization. (In this connection Dr. Littlehales's absence from Madrid is to be especially deplored.)

Commission of the Mediterranean made a report of primarily European interest.

Commission on Tides made a report in which the importance of records on oceanic islands was emphasized, also need for standard method by all nations for recording tidal currents. Need for joint study of mean sea level by oceanographers and geodesists was emphasized. Questions of local interest were discussed. Need for tide observations on the high seas was brought out. Co-ordination of methods of study of ocean currents and observation of mean sea level was discussed.

Commission for Application of Acoustic Methods to Depth Determination. Little information available to commission at that time, but proposition was made for co-ordination of study and methods and their ap-

plication. International Hydrographic Bureau and individual national services were asked to co-operate.

Publication of National Reports. Reports declared very interesting but too voluminous to publish with limited funds available. Recommended that system be followed similar to that of geodesy of having national reports on oceanography printed in standard manner by each nation. Section of National Unions asked to co-operate.

Commission for Organization of Great International Campaigns. This Commission recommended that the Council for the Exploration of the Sea work in close co-operation with the Union and its President was elected third vice-president of the Section. A committee was appointed to determine on an international organization for the exploration of the sea.

A special report was made on a recommendation for an international expedition. The fact that most nations are unable, by themselves, to carry on such expeditions was emphasized, and the important results to be expected were brought out. A type of vessel was suggested. This expedition would be under the jurisdiction of the International Council for the Exploration of the Sea, and this organization proposed to take up the matter of support from the various countries interested.

American Naval plan was described. These plans do not interfere (except that American co-operation in the general plan is likely to be reduced if the naval plan is put into effect).

U. S. Coast and Geodetic Survey,
Washington, D. C.

RESOLUTIONS

RESOLUTION ON THE DEATH OF DR. JOHN FILLMORE HAYFORD, ADOPTED AT THE ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION, MAY 1, 1925

(Resolution was submitted by Section of Geodesy.)

Whereas, We, the members of the American Geophysical Union, have learned with sincere regret of the death, on March 10, 1925, of our associate, Dr. John Fillmore Hayford, Director of the College of Engineering of Northwestern University, therefore be it

Resolved, That we express our deep sorrow in the loss of this member, whose active work in the American Geophysical Union began with its organization in 1919. He held the office of Chairman of the Section of Geodesy from July 1, 1922, to June 30, 1924, and, not being eligible for immediate re-election, that of Vice-Chairman from July 1, 1924, until the time of his death.

Dr. Hayford enjoyed world-wide renown in the realm of geophysical science. For a number of years he was in general charge of the geodetic field and office work of the U. S. Coast and Geodetic Survey, during which time he unified the triangulation systems of the entire country by basing them upon a single point and on one spheroid of reference. He derived, from triangulation and astronomical data in the United States, a new spheroid which was adopted in 1924 by the Section of Geodesy of the International Geodetic and Geophysical Union as being the most reliable in existence and the one recommended for use in all scientific problems involving the shape and size of the earth and in all mapping and charting purposes by those countries which have not already adopted a spheroid for such work.

Dr. Hayford, while in charge of the geodetic work of the U. S. Coast and Geodetic Survey, was instrumental in initiating the revision of field and office methods and practices in conducting geodetic work, leading to greater efficiency and economy. He made the first comprehensive quantitative investigation of the theory of isostasy and thereby proved its validity. In recognition of this he was awarded, early in 1924, the Victoria Medal by the Royal Geographical Society of London.

During the war, Dr. Hayford was a member of the Advisory Committee on Aeronautics and, at the time of his death, was a Research Fellow of the Carnegie Institution of Washington, carrying on investigations concerning the levels of water in the Great Lakes.

The long list of scientific reports and papers by Dr. Hayford forms his fitting and lasting memorial.

Resolved, That the members of the American Geophysical Union re-

gret the death of Dr. Hayford as a personal loss as well as a loss to the science of this country and the world, and that they express to his family their deepest sympathy.

Resolved, At the annual meeting of the American Geophysical Union, held on May 1, 1925, that a copy of these Resolutions be sent to Dr. Hayford's family and that they be spread on the Minutes of the Union.

RESOLUTIONS ON THE DEATH OF DR. ROBERT SIMPSON WOODWARD, ADOPTED AT THE ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION, MAY 1, 1925

Whereas, We, the members of the American Geophysical Union, have learned with deep regret of the death of our associate, Robert Simpson Woodward, who, after a lingering illness of 18 months, peacefully passed away on June 29, 1924, in the seventy-fifth year of his age, therefore be it

Resolved, That we express our deep sorrow in this loss of one who took a prominent part in the formulation of the initial plans which led to the ultimate establishment of this Union. Dr. Woodward's contributions to the various branches of geophysics, notably geodesy, are too well known to require enumeration here. He held positions of responsibility, both in governmental and university affairs, and was President of the Carnegie Institution of Washington from December, 1904, to January 1, 1921, when he voluntarily relinquished this position. He was the recipient of many honors, both from universities and learned academies. We cherish the memory of our late fellow member, not alone for his scientific achievements, but also for his sturdy philosophy and ever-hopeful outlook.

Resolved further, That the Secretary of the Union be instructed to transmit a copy of this Resolution to Mrs. Woodward, and that it be spread on the Minutes of the Union.

RESOLUTION IN REGARD TO CERTAIN COUNTRIES

Resolved, That the American Geophysical Union request the National Research Council to instruct its representatives at the meeting of the International Research Council, to be held in July, 1925, to endeavor to secure favorable action on the recommendations passed by the Division of Foreign Relations on April 26, 1925, with respect to future adhesion of countries to the International Research Council and to its several Unions, and the power of Unions to make, from time to time, such changes in their own statutes as circumstances may require.

RESOLUTION REGARDING PROPOSED U. S. OCEANOGRAPHIC EXPEDITION

Whereas, The Secretary of the Navy recently convened a conference to consider all matters pertaining to a proposed U. S. Naval Expedition for research in oceanography, and

Whereas, Such a cruise unquestionably will be fruitful of results of interest to oceanographers and of value ot mankind, and

Whereas, The American Geophysical Union has interest in all matters dealing with oceanography, and particularly with the securing of quantitative data thereon,

Resolved, That the American Geophysical Union endorses the plan for such an expedition and expresses the hope that the necessary funds may be forthcoming from the United States Government to put it into effect.

RESOLUTION REGARDING THE TOPOGRAPHIC MAPPING OF THE UNITED STATES

Whereas, The President of the United States has been authorized, by the passage of what is called the Temple Act, which became law on February 27, 1925, to complete the topographic mapping of the United States within the next twenty years, and

Whereas, The completion of this topographic mapping will be of great and permanent advantage and value to many activities of the Government of the United States and of the general public, and

Whereas, Scientific investigations of many kinds involving the welfare of our people depend for their successful conduct and completion on a knowledge of geographical location, elevation and configuration, and

Whereas, Any money spent in topographic mapping should be considered as an investment rather than as a running expense of the Government, therefore be it

Resolved, That the American Geophysical Union expresses great pleasure at the enactment of the bill for the completion of the topographic mapping of the country and hopes that the President of the United States will include in the Budget for the year 1927, to be presented at the next session of Congress, an amount of money sufficient properly to initiate this important work.

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ABSTRACTS OF REPORTS AND PAPERS

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SECTION OF GEODESY

SOME GEOPHYSICAL PROBLEMS

R. L. Faris

Geodetic Operations.—In the beginning of geodetic operations the controlling interest appears to have been to arrive at a more certain knowledge of the exact size and shape of the earth; and, again, to find some exact and reproducible natural unit of linear measure.

The next application of the trigonometric method was in fixing of control points (their latitudes and longitudes) upon which to construct topographic maps of land areas of countries. And, yet a little later on, to hydrographic surveys for charting the sea coasts and connecting waters.

Today the immediate application of geodetic operations finds its practical and economic use for mapping and charting purposes, and in the fixation of international, state, and other boundary lines.

Geodetic Data for Maps and Charts.—The general topographic mapping of the United States has been recently wisely recognized by our National Congress as a project of the Federal Government, to be carried out in a definite period of years.

This project will require, for its proper execution, a more detailed extension of geodetic control over the whole country than exists at the present time.

With this will also come, of necessity, further extension of the lines of precise levels over the country, so that the elevations shown on the maps may also have the proper control, and all be referred to a uniform datum, which is now the generally accepted one of mean sea level.

Importance of Maps and Charts.—It is perhaps here unnecessary to restate the great importance of accurate maps and charts in the commerce and the industrial activities and development of our country, and in the economic utilization of our natural resources. None of these things can be properly considered or initiated without the assistance of topographic maps as a guide in their establishment. From the standpoint of the so-called natural sciences, topographic maps are essential to a clear presentation of many important facts and relations. In comparative biology, for example, the geographic position and elevation are important facts in the classification and arrangement of fauna and flora, just as at sea the configuration of the ocean bottom, temperatures, currents, and the depth of water are essential to a clear understanding of marine life and its development and growth. The geologist must have maps or his geologic surveys and studies cannot be correlated. In fact a

roster of those who must make use of maps includes those who work in almost every branch of science, industry, and commerce. In this day, maps are an every day necessity. When the importance of maps in the daily life of a nation is thoughtfully considered it is at once seen that the project recently adopted by Congress for the mapping of our country was indeed a wise provision for the public welfare.

Mean Sea Level.—Reference has been made to mean sea level as a datum plane for topographic mapping. The determination of mean sea level is also a fundamental problem of geophysics. Its determination is not the simple problem that a casual view of the ocean surface might lead any one to infer. Mean sea level is a local phenomenon where stations are individually considered, as in the case of its application to topographic mapping. But as a geophysical problem it is found to have variations from year to year, and through a period of years. All of its variations are not yet known nor their causes understood in detail. Therefore, it is yet a problem of prime importance for systematic observation and study.

Velocity of Light, a Linear Measure.—Our unit of geodetic measure is the length of an arbitrary metal bar under certain prescribed physical conditions. The recent experiments of Dr. Michelson in the determination of the velocity of light when carried to further verification and completion give promise of yielding a new method of measuring terrestrial distances which would have a very practical bearing on geodetic operations, especially in regions of difficult accessibility, such as the Alaskan peninsula and the Aleutian Islands. This method for distance measures, together with latitude observations and radio longitude determinations, would greatly expedite the geodetic operations of ascertaining geographic positions in such regions. It is hoped that Dr. Michelson may pursue those experiments to a successful conclusion.

The Standard Spheroid.—I have emphasized the practical applications of geodetic operations more especially, inasmuch as the earlier intent of geodetic work (that of the determination of the size and shape of the Earth) seems now to have been satisfactorily concluded in the adoption of the Hayford Spheroid by the International Geodetic and Geophysical Union. The dimensions of this spheroid will serve all practical purposes for the future; and possibly for scientific purposes as well, as it appears from a study made by Lambert, "that Hayford's Spheroid of 1909, with corrections for topography and isostatic compensation, may be taken as representing our best present knowledge, and it seems probable that future determinations will give nearly the same results.

Isostasy an Established Fact.—For more than half a century the degree of stability of the Earth's crust (the so-called lithosphere) has been a live question for observation, study, and hypotheses. At the last

meeting of the International Geodetic and Geophysical Union the results of these studies reaped their reward by a definite recognition by that expert international body, of the validity of the theory of isostasy which the late Prof. Hayford did so much to establish as a fact of geophysics.

It would appear that investigators in other lines of geophysics may now study the question of the application of the fact of isostasy to their problems, inasmuch as isostasy does tell us of certain subcrustal conditions that could not be so definitely arrived at in any other way. It seems proper to inquire if their theories should not now be revised so as better to harmonize with the known facts of isostasy. This will require an alteration in the accepted views concerning certain aspects of some of the geophysical sciences. Nevertheless the facts of isostasy must now be reckoned with, and no longer denied their rightful place in the consideration of the mechanics of the Earth's crustal evolution.

Gravity Observations on Land and Sea.—Gravity observations have now been satisfactorily carried out at sea by Dr. Meinesz of the Dutch Geodetic Commission by using pendulums on board a submarine. It is most desirable that many more gravity observations be made at sea in order that more certain knowledge may be had of the isostatic condition of the Earth's crust under the vast ocean areas. While the observations of Meinesz gave good results yet it seems to be of importance to devise if possible some instrument and method which will give the required results with less effort of observation and computation, so that the determinations of gravity at sea may be expedited, and the amount of needed data may be increased more rapidly and to the desired extent.

On land, the gravity determinations, in addition to furnishing data for the determination of the shape of the Earth and for isostasy investigations, also have useful applications in other branches of geophysics, and in the exploration of our natural resources. It is desirable, therefore, that instruments for gravity determinations may be simplified to the end that more data may be obtained with less use of time and effort than is possible with our present apparatus and methods.

Variation of Latitude.—In view of recent theories regarding the Earth's crustal movements, the purposes for which the variation of latitude stations were established have since taken on a new significance. The observations at these stations, in conjunction with the proposed world belt of radio longitude determinations, should in time yield data sufficient to enable us to evaluate the probability of the truth of such hypotheses. Should such crustal movements be found to exist, we may then find the need to revise our ideas concerning a number of the phases of geophysical problems including the variation of latitude itself, in the event that such crustal movements should be found to have an element of periodicity in them. The carrying out of the radio longitude

determinations and the continuance of the variation of latitude observations give much promise of definite results of value aside from their prime astronomical purposes.

U. S. Coast and Geodetic Survey,
Washington, D. C.

THE NATIONAL TIME SERVICES OF THE WORLD

J. C. HAMMOND

This paper gave the results of recent time determinations made at the U. S. Naval Observatory with two instruments and the comparisons by means of wireless signals of the time determinations made at different national observatories during the past two years.

The two instruments were the 6-inch transit circle and a portable transit of 3-inch aperture made by Prin of Paris, each instrument being equipped with an impersonal micrometer. The same stars were observed each night on both instruments and the transits were recorded on the same chronograph so that the comparison was not affected by any errors in the star places nor by any lag of relays.

The monthly mean differences, in the sense Prin minus 6-inch, are:

Month	Difference in clock corrections	No. of nights	Month	Difference in clock corrections	No. of nights	Month	Difference in clock corrections	No. of nights
1922	s		1923	s		1924	s	
Nov....	+0.001	10	Aug....	+0.030	10	May..	+0.004	8
Dec.....	+ .005	9	Sept...	+ .011	10	June..	+ .011	8
1923			Oct....	+ .013	12	July..	+ .025	12
Jan.....	+ .006	11	Nov...	+ .001	12	Aug...	+ .030	6
Feb.....	− .015	8	Dec...	− .003	11	Sept...	− .010	6
Mar.....	− .002	12	*1924*			Oct....	+ .002	8
April...	+ .010	11	Jan....	− .012	10	Nov...	+ .028	7
May....	− .007	12	Feb...	+ .002	11	Dec...	+ .016	6
June....	− .026	8	Mar...	+ .009	10	.....	.....	.....
July....	− .001	9	April..	+ .008	11	.....	.....	.....

The close agreement between the two instruments indicates that the fluctuations which occur in radio time comparisons can hardly be attributed to instrumental errors in determining the time.

The wireless time signals from Annapolis and those from Bordeaux, France, are now received regularly at Washington, Paris, Greenwich, and Ottawa, so that we have a continuous daily comparison of the time determinations made at these four observatories.

The comparisons of the time determinations made at the Naval Observatory with those at Paris, Greenwich, and Ottawa, in so far as they were available, are:

Period	W—P from Bor. signals	W—P from Ann. signals	W—Gr from Ann. signals	W—Ott from Ann. signals
1922				
Nov. 1–15	+0.11		−0.06	+0.04
" 16–30	+ .12		− .05	+ .10
Dec. 1–15	+ .10		− .01	+ .05
" 16–31	+ .08		− .05	+ .01
1923				
Jan. 1–15	+ .08		− .05	− .12
" 16–31	− .01		− .04	− .06
Feb. 1–14	− .03		− .01	− .01
" 15–28	− .06		− .01	− .05
Mar. 1–15	− .15		+ .02	− .08
" 16–31	− .07		− .02	− .02
Apr. 1–15	− .04		+ .04	.00
" 16–30			− .06	− .02
May 1–15			− .05	− .02
" 16–31			− .07	− .02
June 1–15			− .02	.00
" 16–30			+ .01	+ .02
July 1–15			− .11	.00
" 16–30			− .07	.00
Aug. 1–15			− .15	.00
" 16–31			− .04	+ .04
Sept. 1–15			− .10	+ .01
" 16–30			− .07	.00
Oct. 1–15			− .08	+ .01
" 16–31	− .02		− .15	− .04
Nov. 1–15			− .14	.00
" 16–30	.00		− .03	+ .02
Dec. 1–15	+ .05			− .02
" 16–31	+ .03		− .04	− .04
1924				
Jan. 1–15	+ .02		− .04	
" 16–31	+ .01	−0.09	− .06	
Feb. 1–15	− .06	− .16	− .04	
" 16–29	− .04	− .16	− .01	
Mar. 1–15	− .04	− .13	− .03	
" 16–31	+ .11	− .13	− .04	
Apr. 1–15	+ .12	− .14	− .01	
" 16–30	− .02	− .11	− .09	
May 1–15	− .03	− .14	− .13	
" 16–31	− .06	− .15		
June 1–15	+ .02	− .18	− .11	
" 16–30	− .11	− .19	− .14	
July 1–15	− .08	− .18	− .17	
" 16–31	− .10	− .20	− .12	
Aug. 1–15	+ .02	− .18	− .11	
" 16–31	.00	− .14	− .07	
Sept. 1–15	+ .01	− .11	− .04	
" 16–30	+ .01	− .13	− .01	
Oct. 1–15	− .03	− .15	− .05	
" 16–31	+ .07	− .19	− .05	
Nov. 1–15	+ .09		− .10	
" 16–30	− .01	− .20	− .06	
Dec. 1–15		− .12	− .06	
" 16–31		− .08	− .03	

The comparisons of Washington with Paris and Greenwich indicate a seasonal variation with amplitude of about 0ˢ.1. By comparing the two columns headed W—P, it is evident that there are fluctuations of 0ˢ.1 or more, which must be attributed to causes inherent in the reception of the signals. The comparisons between Washington and Ottawa show little variation during the last nine months of 1923.

U. S. Naval Observatory,
Washington, D. C.

GEODETIC INSTRUMENTS FROM THE VIEWPOINT OF THE PHYSICIST

LEWIS V. JUDSON

In connection with my work at the U. S. Bureau of Standards in the calibrating of various geodetic instruments and in the preparing of occasional specifications for instruments of this sort as well as in consequence of my visit to European standardizing laboratories I have become deeply interested in this subject. As I have been fortunate in my opportunities for seeing and working with geodetic instruments in several countries, a brief critical description of a few of these may be of some interest. A discussion of these leads naturally to some remarks on geodetic instrument design, and then to a brief outline of the efforts being made in the Section of Length Measurements at the Bureau of Standards to cooperate in geodetic work.

The apparatus used in the standardizing of base line tapes is different in the different countries. (Illustrations of these comparators which were shown as lantern slides will be included in a more detailed paper which it is proposed to prepare for publication.) The apparatus used at the Bureau of Standards is in its essential features the Woodward apparatus with several important changes made in it, in order to enable it to be used efficiently as a laboratory rather than a field apparatus. The five-meter bar, which is kept in melting ice when in use, has been standardized many times and its length is now known to be constant to a high degree of precision.

Several years ago it was my privilege to see the tape-standardizing installations at the Geodetic Survey of Canada and at the Topographical Surveys Laboratory, both located in Ottawa. The apparatus at the Canadian Geodetic Survey Laboratory is similar to that at the U. S. Bureau of Standards; that at the Topographical Surveys Laboratory is a specially designed Geneva Society instrument. A similar comparator is at Belgrade, and while at Geneva in 1923 I was shown a third one with several improvements made for the Swedish Government. A specially designed 4-meter invar standard is used. The instrument is

capable of rapid use, but requires careful attention to the standardization of the four-meter bar.

The geodetic tape comparator at the International Bureau of Weights and Measures near Paris is of considerable interest, as many tapes for the geodetic surveys of various countries have been standardized there. Provision has been made for securing a new comparator, as the present one is not suited to the demands of precision required in modern geodesy. The base or distance with which tapes are compared consists of reference marks on plates firmly attached to the wall of the building.

Throughout Europe four-meter bars are used quite generally as the basis for geodetic standardization. The Russian Government possesses the most elaborate and precise comparator for standardization of four-meter bars in the world. In a test of this apparatus with Professor Blumbach at the factory of the Geneva Society when it was constructed, I found many excellent features of the instrument. Rigidity, precision and convenience of operation are three of these qualities.

The museums of Europe contain much material showing the development of instrument making. Apparatus of the early days of hand filing, of constructing instruments from plates and from blocks of metal, and of elaborate tracing and carving attract the attention.

The modern geodetic instrument must embody the best construction, using the methods of the best machine and instrument shops and taking advantage of all the resources of our scientific laboratories. The materials of which the instruments are to be made need to be carefully selected in order that those with proper physical properties may be used. The possibility of a wider use of the interferometer should be kept in mind. The method of finishing of those parts which must move freely, and many other points must be carefully considered.

Plans are now under way whereby the Length Section of the Bureau of Standards will be in a position to co-operate in a number of ways in geodetic work. The work of standardizing the base line tapes and of making necessary investigations and improvements in the graduation and calibration will continue. A study of the materials used in making tapes is also in progress. A new field is that of angle measurement, the Bureau now being in possession of an instrument especially designed for the calibration of graduated circles. Later, when a high-precision circular dividing engine is received, we shall be in a position to aid by undertaking investigations in circle graduation and by furnishing such special graduated circles as the manufacturers do not care to handle. The materials suitable for use as instrument circles will also be studied.

In this study of geodetic instruments I have so far merely outlined our problems. The problems themselves are still ahead and the solutions can only be obtained by co-operation.

Bureau of Standards,
U. S. Department of Commerce,
Washington, D. C.

THE NETWORK OF PRECISE TRIANGULATION AND LEVELING OF NORTH AMERICA WITH SPECIAL REFERENCE TO USE IN TOPOGRAPHIC MAPPING

C. V. Hodgson

I wish to present briefly a progress report on the present status of our national horizontal surveys, using for purposes of illustration a lantern slide which represents the first order control established by the United States Coast and Geodetic Survey and other organizations.

It is expected that by next autumn the Coast and Geodetic Survey will have completed two large projects upon which it has been engaged for a number of years. This diagram shows the system of first order triangulation and traverse as we expect it to be at the end of the coming field season. The first large project, a co-operative one between the Coast and Geodetic Survey and the Geodetic Survey of Canada, is the execution of a belt of first order control spanning the international boundary and extending from Lake Superior to the Pacific Ocean. The Geodetic Survey of Canada is executing the section from the 109th meridian to the Lake of the Woods, and the Coast and Geodetic Survey the remainder. This first order control is connected at frequent intervals with the third order triangulation of the International Boundary so that the boundary surveys will be strongly tied in to the basic surveys of the two countries. It has taken four years to complete this project, because of the very difficult conditions of the terrain. The western end crosses very rugged country where transportation of the field parties is by pack train only. Along part of the northern Minnesota boundary the transportation was by canoes and back-packing, while on the section along Rainy Lake and Lake Namakan, first order traverse was run over the ice in mid-winter, with an average temperature while taping of −5° F.

The second project would perhaps be more properly called the general plan for the initial development of first order control west of the 98th meridian. Of the belts of triangulation shown on the sketch we shall have completed, during the field seasons of 1925 and 1926, the western end of the 49th parallel along the northern boundaries of Idaho and Washington, the cross belt extending across eastern Washington

from Oregon to the International Boundary, the arcs across South Dakota, Wyoming and Montana from the 98th to the 111th meridian arcs, the arc from Needles, California, to the vicinity of Salt Lake and the short arc from near San Antonio westward to the Rio Grande. As you see, the western half of our continent is thus divided up into blocks of from 200 to 400 miles across. With this general plan completed, we are now in a position to bridge in a few months, by triangulation or traverse, any of these areas between triangulation belts, and thus in a single season's work be able to establish final adjusted geographic positions over any area west of the 98th meridian.

The timeliness of our arrival at this preliminary goal is apparent when we consider the import and scope of the Temple Act, passed by the last Congress, which provides for the completion of the fundamental topographic map of the country in twenty years. To complete the topographic map it is necessary first to complete the various grades of control over the country. In order to provide for a proper development of the remaining horizontal control the Federal Board of Surveys and Maps is considering a plan under which each of these areas lying between the existing belts of first order control will be systematically developed with the required amount of first, second and third order control. Coincident with the prosecution of this plan it will be necessary further to subdivide the three or four large areas in the east which still are lacking in first order control. While much remains to be done, it is gratifying to see a long-cherished plan gradually reaching fulfillment.

In this progress report, I have anticipated the probable action of the Board of Surveys and Maps which is considering the adoption of a new system of nomenclature for the various grades of horizontal control surveys. Prior to 1921 the words primary, secondary and tertiary were used to designate the three upper grades of triangulation, in order of accuracy. In 1921, the representatives of the Federal map-making bureaus composing the Board of Surveys and Maps agreed upon the terms precise, primary, and secondary to designate the three higher classes of control. Since this has led to confusion, it is now proposed to adopt the terms first, second and third order which, it is believed, will be self-explanatory and which will be closer in accord with international usage. The reports of the committee of the Section of Geodesy of the International Geodetic and Geophysical Union, on standards and nomenclature for the various grades of triangulation, are not to be presented until the next meeting at Prague in 1927, but we trust that the terminology recommended by that committee will not differ greatly from that which the Federal bureaus here will adopt. At any rate, the ex-

pected increase in geodetic surveying in this country, under the provisions of the Temple Act, made it inadvisable to delay longer in selecting terms which would be more easily understood.

U. S. Coast and Geodetic Survey,
Washington, D. C.

PRECISE TRIANGULATION AND TRAVERSE

W. F. Reynolds

The adjustment of the arc of precise triangulation, beginning at Puget Sound in the northwestern United States, extending northward along the coast of British Columbia to Dixon Entrance, Alaska, and thence through southeastern Alaska to Skagway, has now been completed up to about latitude 57° in Frederick Sound, Alaska. This is one of the cooperative schemes of triangulation being carried out by the Geodetic Survey of Canada and the United States Coast and Geodetic Survey. It is planned to complete this adjustment within the next year, and then it will be possible to put all the triangulation of southeast Alaska on the North American Datum.

On account of the difficulties encountered, the adjustment of the precise triangulation of the United States has been somewhat retarded in the last few years. In the early days of the Coast and Geodetic Survey the adjustments were very simple, the work being caried ahead directly, there being no fixed positions to be held. The Transcontinental arc and the Eastern oblique arc, while very large arcs, presented no serious difficulties, as the adjustments were made in sections, only the lengths of the measured bases being held.

But when the triangulation became so extensive that loops were formed, discrepancies in latitude and longitude arose. According to our methods, the work first adjusted was held fixed, and the discrepancies distributed in the portion of the loop last completed. This sort of adjustment, while making things consistent, was not fair to the new work, for although as good as the old work it necessarily caught large corrections to make it fit in properly.

As more and more loops were closed the situation became worse, the new arcs receiving much larger corrections than their accuracy justified. It was first proposed to readjust all the precise triangulation and precise traverse of the United States in one piece, holding only the measured bases and Laplace azimuths, and the geographic position of Meades Ranch, Kansas, which is now the initial for the North American Datum. This would probably be the ideal way to make the adjustment, but when it was considered that it would mean the formation and solution of about 3,500 normal equations, the plan was abandoned.

Major Bowie, Chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey, suggested and outlined, about a year ago, a general plan for the readjustment of the triangulation which it is believed solves our problem. Dr. O. S. Adams, at the request of Major Bowie, investigated the plan and devised a practical method of making the adjustment. Under this plan the discrepancies in loop closures are distributed by a method similar to that used in the adjustment of a precise level net.

The method may be described in general as follows: At each of the junction points of the various arcs a length and azimuth of a line is held fixed. If there is no measured length at the junction, a weighted mean of the various lengths determined by carrying the measured lengths of the nearest bases through the observed angles, is adopted. If no Laplace azimuth is available at the junction, the weighted mean of the various azimuths obtained by carrying through the nearest Laplace azimuths by the most direct route, using the observed angles, is adopted. The only geodetic position held in the adjustment is that of Meades Ranch. Using this position as a starting point, preliminary positions are computed and the best available positions of the junction points of the arcs are determined.

The differences of latitude between the various junction points are considered as observations and weighted inversely as the distances. The discrepancies in loop closure for latitude are then adjusted in the same manner as the adjustment of trigonometric leveling is made. In the same manner the discrepancies in loop closure for longitude are made.

In this way, at each of the junctions of the various arcs of triangulation we have a line fixed in position, length and azimuth, so that as many computers can be put on the adjustments as there are arcs between junction points.

It is the present intention to readjust all of the precise triangulation in the United States west of the 98th meridian by this method. Later it may be necessary to apply the same method to the triangulation in the eastern part of the country.

As this method was suggested by Major Bowie, Chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey, it will be known hereafter as the Bowie method of adjustment for an extensive net of triangulation.

U. S. Coast and Geodetic Survey,
Washington, D. C.

GEODETIC ASTRONOMY AND GRAVITY

C. H. Swick

Most of the recent astronomic work by the Coast and Geodetic Survey has been done in the western part of the United States and the work this year will also be west of the 98th meridian. Quite a large part of this work is in preparation for the proposed readjustment of the triangulation net of the western part of the country, in order to furnish more accurate data for the junction points.

During the past three years the wireless method has been used very successfully for longitude determinations. We now have twenty-six wireless longitudes. Several minor improvements have been made in the apparatus and methods, and changes are still being made, especially in matters of standardization and simplification of the apparatus and in making it more rugged against transportation shocks.

In addition to the usual office astronomic computations during the past year, an important publication by Miss Sarah Beall giving complete data for all astronomic stations in the United States has been completed and printed and will soon be ready for distribution. It is Special Publication No. 110.

As far as field gravity work is concerned we have been principally marking time during the past year, because of the great promise of Dr. Wright's new gravity apparatus and the possibility that Prof. Michelson will be able to perfect his new "interfergravometer." We have made only two gravity determinations since a year ago, one at Pasadena at the request of Dr. Millikan, and the other on Mt. Wilson at the request of Professor Michelson. Prof. Michelson, at the suggestion of Major Bowie, used one of the gravity pendulums as a time-piece for his new determination of the velocity of light, as he considered it the most accurate time-piece he could obtain for the purpose.

Two other pieces of co-operative work should be mentioned, one a gravity determination at Oberlin College made by Prof. L. W. Taylor, head of the Physics Department, using an apparatus loaned to him by the Survey, and the other a gravity determination at the University of Buffalo made by Prof. Edward Moore, using an apparatus borrowed from Cornell University which will be standardized for him at the base station here.

The Coast and Geodetic Survey has undertaken to compute the topographic and isostatic corrections for the sea stations determined by Dr. Meinesz of the Netherlands. The computations have already been made for about a dozen stations in the Indian ocean and show the isostatic anomalies to be very close to zero, especially over the deep part of the ocean. Near Ceylon and the southern tip of India, the anomalies are

larger and negative in sign but the isostatic anomalies at several land stations in the southern part of India as computed by the Trigonometrical Survey of India, have the same negative tendency.

At the meeting at Madrid of the International Geodetic and Geophysical Union the Chairman, Major Bowie, proposed that, if any countries wished to have the isostatic reductions made for their gravity stations and could not well undertake the work themselves, they request the Coast and Geodetic Survey to take charge of the work for them. Already, Spain and the Netherlands have asked for estimates, Spain for about 40 stations and the Netherlands for about 50. The work will be done by mathematicians of the Survey working after office hours.

Although quite a large number of gravity stations in various parts of the world have now been isostatically reduced, the distribution of these stations is not as wide as is desirable. There are practically none in the southern hemisphere. To meet this need the Philosophical Society of Washington has made a grant of $100 and the isostatic reductions for five gravity stations on the New Hebrides Islands are now being made by mathematicians of the Survey, working on outside time.

U. S. Coast and Geodetic Survey,
Washington, D. C.

THE VARIATION OF LATITUDE

WALTER D. LAMBERT

The work of reducing the observations made at the three remaining international latitude stations has been, since September, 1922, under the direction of Prof. H. Kimura who has recently published preliminary results.

There is a serious gap in the definitive reductions of the international stations; these have been published only through 1912. The Reduced Geodetic Association among Neutrals, which was formed to keep alive scientific geodesy during the World War, has devoted its remaining resources to the completion of these reductions. These resources having proved inadequate, the Section of Geodesy of the International Geodetic and Geophysical Union, as the successor organization, has accepted the obligation to make up the necessary sum. The work will be under the very competent direction of Prof. Wanach, of the Prussian Geodetic Institute.

The international latitude station at Charjui in Russian Turkestan had been lost since the early days of the World War but it now appears that work was continued there until May, 1919, and that the records are safe. They will doubtless be turned over to Prof. Wanach.

The problems of the variation of latitude are far from being com-

pletely solved. If the earth were absolutely rigid, its free period would be ten months and not fourteen. This lengthening of the period gives us a means of estimating the elasticity of the earth but, on account of irregularities in the observations, we do not know to a day just how long the 14-month period is nor do we know just how much of the lengthening is due to the yielding of the ocean water by flow rather than to the elastic yielding of the solid portion of the globe.

Then we should like to know also why the free period is not damped out by friction. Jeffreys showed that internal friction, large enough to account for the otherwise unexplained apparent secular acceleration of the moon would very promptly damp out the free oscillation; he also found enough oceanic tidal friction to account for the moon's motion, and concluded that internal friction in the solid part of the globe must be small; nevertheless we cannot think of the free oscillation as absolutely unattended by frictional resistance, although there is no clear observational evidence.

The most important question in latitude variation, particularly in secular or quasi-secular variation, is that of crustal movement. The observations of the International Latitude Service make it clear that there have been changes in latitude beyond what can be explained by the known annual and 14-month terms, changes such as to suggest a small quasi-secular shifting of the pole, or else crustal movements. After study I came to prefer the hypothesis of quasi-secular shift of the pole as affording the most satisfactory explanation of the observed latitudes of the International Service. The general problem of crustal movements was discussed only incidentally. Kimura's recent results tend to confirm my opinion. Those who would attribute quasi-secular changes in latitude to crustal movements are not agreed as to which one of the international stations had done most of the moving. All the remaining stations are, however, in country that, on geological or seismological grounds, is at least open to suspicion of instability.

No satisfactory solution is to be had unless we can determine crustal movements by evidence independent of the astronomical latitudes, or unless we increase the number of our astronomic stations and locate them in comparatively stable regions. We could probably get the most valuable results for the least money by reoccupying Charjui and Gaithersburg.

Latitude determinations by the zenith telescope are dependent on star places. The advantage of having all stations on the same parallel is that they can use the same observing program. Corrections to the star placed can be determined from the observations themselves. These corrections are important in various astronomical problems; for instance, they affect the determining of the sun's motion through space.

The international stations are not the only ones where perplexing changes of latitude have occurred. Rome has apparently changed its latitude by 1.43″ since 1855. A systematic study of such anomalies would be highly desirable. Some of the great observatories are making special studies which will doubtless help us to answer some of our questions, especially in regard to the free oscillations and other oscillations suspected but not proved. Almost any observatory having a good meridian circle could help by conducting a series of absolute determinations of latitude which ought also to be useful in preparing star catalogues.

In one aspect, and that one the most important in the popular mind, namely the climatological aspect, these shiftings of the pole or these crustal movements are insignificant; but from other geophysical points of view the importance of these problems is evident.

The whole subject may perhaps be fitly summed up by enlarging the application of a remark made over 100 years ago by Delambre, but quite as true as when it was uttered:

"The questions of the size and shape of the earth and of the variation of latitude which so long have taxed the skill of mathematicians, astronomers and geophysicists, seem by their very nature to be inexhaustible."

U. S. Coast and Geodetic Survey,
Washington, D. C.

PROJECTIONS FOR MAPS

New Conformal World Maps Derived from Elliptic Functions

OSCAR S. ADAMS

This paper gave a short resume of the history of the subject under consideration, and then a number of slides were shown to illustrate what had previously been done along this line and to show what recent advances have been made in this type of conformal mapping. The slides were the important part of the presentation; the full theory and the analytical development have been published in Special Publication No. 112 of the U. S. Coast and Geodetic Survey, entitled, "Elliptic Functions Applied to Conformal World Maps."

In 1864, H. A. Schwarz, of Halle, pointed out that a circle could be mapped conformally in a regular polygon of n sides by means of the integral

$$w = \int_0^x \frac{dx}{(1-x^n)^{2/n}}$$

The same thing was shown by Weirstrass of Berlin in 1866.

In the report of the Superintendent of the U. S. Coast and Geodetic Survey for 1877, C. S. Peirce, at that time an Assistant in the Survey, published an account of such a projection which he called the quincuncial projection of the sphere. This was the first conformal projection depending upon elliptic functions that was computed and constructed for geographic purposes.

In the ninth volume, second series, 1887, of the Annales Hydrographiques, Lieut. E. Guyou published the theory of a related projection which, however, was derived in an entirely different manner.

Both the quincuncial projection and that of Lieut. Guyou depend upon the lemniscate integral, which is the Schwarz integral with n equal to 4. These two projections for geographic maps are the only ones with which we are acquainted that have hitherto been computed with elliptic funtions as basis.

The author has made computations for a number of new projections depending on the Schwarz integral, several of which are based on this integral with n equal to 3. The publication No. 112 gives a development of the theory of the functions derived from the inversion of this integral. From the properties of these functions the formulas are developed for the direct computation of the co-ordinates of the various projections. Projections of this kind are associated with a rhombus that becomes a square in case n equals 4. For this reason the name of rhombic projections has been given to this general class of world maps.

In the 70th volume of Crelle's Journal, H. A. Schwarz mentioned the possibility of mapping an ellipse conformally on a circle. This statement suggested the idea that the process might be reversed and that a circle might be conformally mapped on an ellipse, or that the sphere coud be mapped in the boundary of such a figure.

In all, nine new projections were shown, some for the whole world, others for a single hemisphere only. Of the eleven projections of this kind, ten of them have been produced by the U. S. Coast and Geodetic Survey.

U. S. Coast and Geodetic Survey,
Washington, D. C.

SECTION OF SEISMOLOGY

ENHANCING THE VALUE OF THE SEISMOGRAM

FRANCIS A. TONDORF

The Section of Seismology of the Geophysical Union appears satisfied that the number of seismic stations in the United States is adequate. It also feels that, though the installations at these stations are not, in

every instance, of a class "A" character, nevertheless all could broadcast data of a valuable nature. In the catalogue of Dr. Wood, Bulletin No. 15 of the National Research Council, i. e., Vol. II, Part 7, twenty-nine observatories are listed, and of these scarcely thirty per cent make any pretense at the issuance of regular reports. The value of these grams, assuming that these stations have their instruments in operation, can be enhanced in the marking of them. Possibly the directors of these plants need to be impressed with the truism that this is a "worth while" issue. Now to the stations rendering reports. One of the first problems of the seismologist is to establish the geography of earth tremors.

Epicenters are best figured out from the times of arrival of the first and second preliminary tremors. How have our grams been measuring up to these times? This may be best noted in a concrete case. The figures are taken from the files of the Georgetown University Seismological Observatory. These files show that in the past nine years 739 quakes have been registered, an average of 83 per annum. Registrations from mechanically recording instruments only are here considered. This establishes a fairer comparison with the other stations in the States, where, for the most part, this type of instrument is in operation. Reading these 739 grams along all three components, i. e., East-West, North-South, and the Vertical, we find that the first preliminary tremor was recognized and its time of arrival read in 556 instances. Of these P is listed in just 100 cases as appearing with a marked on-set, that is, iP. P is catalogued as showing up with an emergence 376 times and as a very questionable wave in 80 cases. On the assumption that the most and probably the only dependable reading is P with a marked on-set, we have, as far as P is concerned, the low figures of 14 per cent for the determination of focal points of quakes. Added to this is the fact that these figures drop considerably because, in not a few instances, iP is mistaken for PR or iS. P as an emerging wave gives P too late. A systematic comparison of photographically registered quakes with those mechanically recorded unquestionably shows this. Where P is masked in microseisms, the tendency is persistent to anticipate the time of P. Now for S. The total number of cases in which this wave's time was read as appearing with a marked on-set was 94 out of the 739 quakes registered. This is 11.4 per cent of the total and 2 per cent below iP. The total reading for S was 360. This low reading, as compared with total for P, is readily explained in that many of the quakes were from very distant points. Taking iP and iS at their maximum appearance as the most dependable data for epicentral determinations, we have at most twelve per cent of the total data available. It is true that where either P or S is entirely obliterated from the gram, there eL may be

substituted for either. But as eL is the more difficult of reading, the error is proportionally greater. The conviction is entertained that a critical analysis of the records of other stations in the States would not only run these figures a close second, but would show them far below; this because the data from our station show the comparative study of grams from three different types of seismographs—a unique condition. All this bespeaks, so it is inferred, weakness in a one-man interpretation. Is there any salvaging these grams? It was suspected at one time that much might be gained by comparing readings of grams from different stations. Confidence was lost in this method because of prejudice for or against the opinion of another.

And this is, at best, but a shifting of the difficulty. A Central Bureau, as suggested by Klotz some years ago, appeals to the writer as the one effective solution of the problem. Klotz fancied it feasible to request stations to transmit all grams to the bureau for evaluation and comment. We are not convinced that this procedure is the most prudent. It might lead stations to suspect that they would thereby forfeit their autonomy. Let the stations be invited to despatch into the Bureau their interpretations with the original grams and the grams returned with such annotations as may appear helpful for future interpretations. The Bureau would thus have the benefit of the gram as interpreted by its committee. This would be salvaging much material hitherto rated as worthless. Thus wise, too, the reliable would be placed in competition with the certain. Much would so be learned, also, regarding the effect of position of instruments, the instruments themselves, etc., on the inscriptions. Anomalies would be transmuted into laws. As seismograms are only an asset to the literature of geophysics when expressed in absolute units, standardization of instruments is imperative. Authority for such standardization should be vested in some bureau. This body should see that all instruments should have their constants fixed on a common basis, rated at stated intervals, etc. The grams then would take on much additional value.

Once the seismogram is thus lifted in value it will become a *deus ex machina* to solve more of the mysteries lurking within the crust of the planet on which man breathes and moves.

Georgetown University, Seismic Station,
Washington, D. C.

SEISMOLOGICAL WORK OF THE COAST AND GEODETIC SURVEY

N. H. Heck

Specific authority to engage in seismological investigation was granted to the Coast and Geodetic Survey on January 31, 1925. Under existing conditions no funds are available for the fiscal year ending June 30, 1926, but in spite of this there has been and will be considerable activity. The activity includes the placing of the work at the magnetic observatories, where it has been secondary, on an equal basis with the magnetic work, and also taking over the activity heretofore carried on by the Weather Bureau, including publication.

An earthquake on February 23 and that in Eastern Canada on February 28, called attention to the need for the entry of the Coast Survey into the field. Attention was called to the difficulty of certain geologists and the press and public in locating this earthquake, several geologists placing it under the Gulf of Maine. Need for a central organization for evaluation of earthquake results was indicated. The February 28 earthquake will be discussed in a report by the Canadian Government, with the co-operation of the Coast and Geodetic Survey, which has received 600 reports of visible and felt effects. These reports show that it was more severely felt in the direction towards Iowa than in the direction towards Virginia.

Information regarding existing seismological observatories throughout the United States has been obtained. Several of the stations are very good and others very indifferent, both as to equipment and attention paid to the work. All are needed to secure complete information, but it is important that two or three should be completely equipped and careful study made of the results. The Coast Survey will concentrate for the present on Tucson, Arizona, a station of peculiar value, since it is near, but not in, the California region. Utilization of results is being given attention, also the avoidance of overlapping and duplication. Fault map was discussed, with the statement that the Coast Survey would not attempt for the present to map epicenters.

Reasons for the Bureau taking up this work were given, including: close relation in methods with magnetic work; carrying on of geodetic surveys in earthquake regions; collection of information in regard to tidal waves; presence of vessels in regions where earthquakes have occurred and may occur; and completion of surveys so that changes due to further earthquakes may be accurately measured; experience in study of seismograms. Surveys of special interest in this connection are those of Monterey Bay, California, where there is a submarine valley with

steep sides, and the examination of ocean deeps off Mexico and Central America by the *Guide*.

The present aim includes: maintenance of popular interest in program; co-operation with existing agencies in collecting earthquake information and scientific investigation of earthquakes, based on the best possible records of high-grade instruments. An Anderson seismometer is being installed at Tucson to replace the worn-out Bosch-Omori instrument.

Value of position of magnetic observatories, which are in all cases near the coast, was pointed out as being of special value for the study of under-sea earthquakes.

Need for seismologists to exercise patience in appraising the progress of the Bureau was emphasized and a promise of steady progress was made.

U. S. Coast and Geodetic Survey,
Washington, D. C.

THE INTERPRETATION OF THE SEISMOGRAM

HARRY FIELDING REID

The first thing to be determined on the seismogram is the time of arrival of the several groups of waves. In connection with data on the time and place of the shock recorded we construct the transmission curve. Although the form of this curve is fairly well known at present it is by no means very accurately known. It serves two important purposes, to locate the origin of earthquakes when not otherwise known, such as submarine shocks or those occurring in uncivilized regions; and it helps to explore the interior of the earth. If the ratio of the elasticity to the density changes suddenly at some depth below the earth's surface, the velocity of transmission will change there and we should expect a slight sudden change in the tangent of the transmission curve. Earlier claims of surfaces of discontinuity were based on supposed changes of the above type; but the accuracy of the transmission curve was not sufficient to yield reliable results.

A new method has been developed, namely, the study of the intensity of the record at various distances from the origin, the differences being due to reflections and refractions at surfaces of discontinuity. Wiechert and his colleagues and the Mohorovicics have given attention to this method and the existence of surfaces of discontinuity in the earth is becoming better and better founded. A great complication arises from the fact that either a longitudinal or a transverse wave will in general at a surface of discontinuity give rise to waves of both types in both media, so that four waves are developed moving with different velocities

and in different directions and each of them must make its mark on the seismogram when it comes to the earth's surface.

The break in the transmission curves at 100° to 120° from the origin has long been known; Wiechert explained it by the existence of a surface of discontinuity. There still remains much work to be done in this field. The method is clear: we must follow the various waves theoretically, and by a careful comparison of the theoretical results with observation we must eliminate errors and confirm truths. The subject is difficult, but not hopeless; and its successful prosecution will do two things: it will explain the characteristics of the seismogram and will teach us much about the interior of the earth. There is no way except by means of earthquake waves of feeling out the earth's interior.

In the report on the California earthquake of 1906, it was shown that the transmission curve of the surface waves, regarded as a straight line, did not pass through the epicentre. This is fairly self evident, for the surface waves must be started by the arrival of the longitudinal or the transverse waves at the earth's surface; and, although these would reach the surface first at the epicentre and might start surface waves there, other surface waves would be started by oblique body waves in front of the former; therefore, the front of this group would originate at some distance from the epicentre. It seems probable that the transverse waves originate the surface waves, for the first phase is quite distinct in nearby earthquakes, but the second phase and the surface waves cannot be separated; moreover, the transverse waves have greater amplitudes than the longitudinal.

As our observations become more accurate we see that the seismogram is very complicated. The mathematicians taught us that there should be body waves and surface waves in a limited elastic medium, and some seismologists tried to find them in the seismogram. Oldham finally succeeded. Thus, by the aid of the mathematicians we may look forward to continued progress in unraveling the secrets still hidden in the seismogram.

The Johns Hopkins University,
Baltimore, Maryland.

SECTION OF METEOROLOGY

A POSSIBLE MEANS OF SAMPLING THE HIGHER ATMOSPHERE

W. J. HUMPHREYS

A few years ago it was widely believed that beyond the level of the highest clouds, or limit of vertical convection, temperature varies but little with height. This belief was based on the fact that in these higher

reaches of the atmosphere the flux of earth radiation is substantially the same at all levels. Furthermore, sounding balloon records greatly strengthened this idea, by showing that in middle latitudes the temperature of the atmosphere is around –55° C. all the way from the top of the highest clouds, say 10 to 12 kilometers above the surface, up to the greatest height attained, 30 to 35 kilometers.

In 1923, however, Vegard argued, from auroral observations, that at great heights, such as 100 kilometers, the temperature of the air is down at least to –225° C.; while Lindemann and Dobson reasoned, from observations of meteors, that beyond the level of 40 to 50 kilometers the temperature of the air must be approximately 30° C.—tropical heat!

Here, then, was confusion as to the temperature of the upper air; and the confusion was as bad, or worse, in regard to the presence at these levels of helium and hydrogen. The situation seemed to demand the unanswerable testimony of direct observations. This demand is not now so urgent as it was, since the evidence in favor of the excessively low temperature of the outer air has been refuted, and that for its high temperature seriously questioned. Nevertheless, we still are without direct and unquestionable knowledge of the state and composition of the higher atmosphere.

A possible general scheme for obtaining these data is as follows:

1. The height will be attained with a rocket of, say, the Goddard type.

2. A hermetically sealed vacuum bulb, surrounded by water and ice to give a constant temperature, as per device used by C. G. Abbot on balloon pyrheliometers, is carried by the head of the rocket.

3. At the top of the flight the tip of a tube drawn out from the vacuum bulb is broken off, and, as soon as the bulb has filled, again sealed up—a scheme used by Teisserenc de Bort.

4. As the tube is being filled a flash light is set off; on a cloudless night, of course, during the dark of the moon.

5. From two or more suitable stations this flash is photographed among the stars, giving a parallax from which the height is readily computed.

We have, then, the temperature, 0°C., and height, at which the bulb was filled, and, as soon as it is recovered, the pressure of the gas in it at this temperature, hence the pressure at the time and place of filling, can easily be determined in the laboratory. Finally, gas analysis will furnish the composition of the captured air.

From a series of such samples, taken at various levels, the temperature distribution is readily found.

Given a suitable rocket, now being developed, the investigation, though requiring skill and ingenuity, certainly is both feasible and worth-while.

U. S. Weather Bureau,
Washington, D. C.

BROADCASTING WEATHER REPORTS FROM THE PACIFIC AND JAPAN BY THE UNITED STATES TO FRANCE

E. B. Calvert

As indicating the foundation already laid for international exchange of radio weather reports the following facts are presented.

The Imperial Observatory at Kobe, Japan, broadcasts three or four times daily weather reports from about twenty stations in Japan, the Philippines, Manchuria, Korea and a few places in China. A similar service is performed by the Philippine Weather Service at Manila. Broadcasts are also made from Honolulu which include reports from two or three places in the Hawaiian Group, including Midway Islands, and certain stations in Alaska and continental United States.

The most extensive broadcast for the Pacific is that made by the U. S. Weather Bureau through the naval radio station at San Francisco at 9:30 a. m. and 7:30 p. m., local time. Major bulletins are broadcast at those hours on 7,000 meters wave length. These bulletins contain reports from nine stations in Alaska, two in British Columbia, three in the northwest Canadian Provinces, thirty in continental United States, Manila and Guam and from eight other places in the Far East. In all fifty-four stations are included in this broadcast. Vessel reports from the Pacific, when and as received, are also included in this broadcast.

So far as the United States is concerned no attempt is made to collect any Far Eastern reports by radio.

Reports from the Far East are collected in that region and forwarded by radio in a message addressed to the U. S. Weather Bureau, to San Francisco, thence to Washington, D. C., by land wires.

Radio exchange of weather reports between France and the United States has been in progress for some time through the U. S. Naval station at Annapolis and the radio station at Lyons, France. Since the present schedule between these two stations is already approaching the overloading point, the inclusion of additional reports covering the Pacific area would have to be taken up and considered broadly by the two countries directly interested.

U. S. Weather Bureau,
Washington, D. C.

METEOROLOGICAL OBSERVATIONS BY AIRPLANES

W. R. Gregg

In the last year of the World War, and in the year following, some 550 observations of temperature and humidity were made in northeastern France by the British Meteorological Section, R. E. The data were used currently in forecasting and were later summarized in an important paper by Capt. C. K. M. Douglas of the British Meteorological Office.

This type of free-air investigation has been continued in Great Britain, a recent report stating that some 300 observations were obtained during the past year. The heights reached are usually about three kilometers, in some cases considerably greater. These heights are determined by means of an altimeter, corrected for air temperature.

Similar observations are made in France, Belgium, and other European countries. In all cases the results are used in forecasting, and in some instances they form the basis for free-air studies. The data themselves have not, however, been published in detail.

In this country meteorological observations in airplanes were first made by the Signal Corps in co-operation with the Weather Bureau at Aberdeen Proving Grounds in 1918. Air density at different heights was computed from the records of pressure and temperature and used in connection with bombing tests. The results were not entirely successful, owing to difficulties in mounting the recording instrument in such a way as to provide good ventilation and at the same time avoid excessive vibration. Nevertheless the data were very useful.

During the Summer and Autumn of 1923, the Weather Bureau, cooperating with the Air Service of the War Department, made several measurements of dust content at different altitudes up to 10,000 feet in airplanes. The relation between dustiness and visibility was studied, and the results were published in the Monthly Weather Review for March, 1924.

Since the war, the aerological section of the Bureau of Aeronautics, Navy Department, has made quite a large number of these observations at its air stations near Norfolk, Pensacola, San Diego, and elsewhere. A particularly interesting series of records was obtained at San Diego during the latter half of 1924. The flights reached one and a half kilometers on the average, and some went as high as two and a half kilometers. The time required was from one-fourth to one-half hour. In addition to the automatic records of pressure, temperature, and humidity, detailed notes were made of weather conditions in general, including particularly the occurrence of fogs and clouds, and heights of the latter, both bases and tops, when measured. Observations of wind

speed and direction were made at the same time with pilot balloons. The data from San Diego are telegraphed to the District Forecast Center of the Weather Bureau, at San Francisco, for use in forecasting.

More recently, during the past month in fact, April, 1925, the Bureau of Aeronautics and the Weather Bureau, co-operating, have undertaken to secure daily, except Sunday, observations in airplanes at the Naval Air Station, Anacostia, D. C. Some of the details have not yet been completely worked out, but in general the plan is to have a flight made at about 8 a. m., so that the data may be available for the forecaster by 9 or shortly thereafter. The plane will "level off" at certain altitude intervals, in order that instrumental lag may be eliminated; the precise altitudes have not been finally selected, but there will probably be four or five in a 3-kilometer flight, one being quite close to the ground and the intervals progressively increasing with height.

Upon the completion of each flight the pressure, temperature, and humidity at certain levels will be quickly computed and telephoned to the forecaster at the Weather Bureau. Height and thickness of cloud layers, when measured, visibility and any other condition of unusual interest will be included.

It is believed that the carrying out of this program will mark the first step in bringing about a desirable and a very effective change in free-air exploration. The use of kites has given us a great deal of valuable information and has up to the present time been the most satisfactory method for this type of investigation in the lower levels. But kites have serious limitations. In the first place, they cannot be used in calms or in very light winds. Again, they cannot be used in or very near populous centers, where means of quick communication are available. Most serious, however, is the fact that the flights require considerable time so that the data, although of great value in research, cannot be communicated to the forecaster quickly enough to be useful in making his forecasts. The current use of the data has therefore been impossible. This will not be true in the case of airplanes, and therein lies their great advantage. In addition, the data secured can be used later in researches just as are those from kites at the present time.

It would seem that, at flying fields of the War and Navy Departments and perhaps others where flights are made regularly, it should be possible through co-operative arrangements to have free-air observations made with little added cost, and there would thus be established a system of observing stations covering the entire country, the data from which would be of direct and immediate benefit to aviation and, more important still, would increase the accuracy of general weather forecasting.

This is the program which we hope will eventually grow out of the arrangements recently made between the Bureau of Aeronautics and the Weather Bureau.

U. S. Weather Bureau,
Washington, D. C.

A FORM OF SIMPLIFIED CALENDAR

C. F. Marvin

The speaker presented orally the latest information that had come to him from a consideration of the subject by a committee of the League of Nations. At the last meeting of that committee (in February, 1925) a definitive step was taken, viz, an agreement was reached on the part of various ecclesiastical authorities to fix the date of Easter, probably at a date early in April. Favorable action was not taken on the 13-month calendar. General comments were made on the several aspects of the subject.

U. S. Weather Bureau,
Washington, D. C.

PRINCIPLES ON WHICH WEATHER FORECASTS IN THE UNITED STATES ARE BASED—AN ILLUSTRATIVE EXAMPLE

Alfred J. Henry

The Madrid meeting of the Section of Meteorology adopted a resolution expressing the wish that the Central Meteorological Service of each country should illustrate by an example the methods on which its forecasts are based.

The day selected should be September 25, 1923, * * * and each country should set out the forecasts for its own area and should relate them to the general situation prevailing over the continent to which that area belongs in such manner as to bring out the scientific principles on which the forecasts are based.

Pursuant to the foregoing resolution, the forecasters in charge of the five forecast districts into which the United States has been divided for forecast purposes, were asked to report upon the methods on which they had made the forecasts for their respective districts on the date specified. These reports have been received, summarized and a copy of the summary and accompanying documents is ready for transmission to the International Secretary of the Section.

The speaker presented the facts above to the meeting and pointed out that each forecaster recognized in the pressure distribution on the

date in question—the position and intensity of cyclones and anticyclones—the dominant control of the weather during the ensuing twenty-four to thirty-six hours. No warm or cold fronts were present, but cognizance was taken of the tendency of cyclones and anticyclones to pursue certain paths at this season of the year.

The influence of topography in causing up and down slope winds was recognized in making the forecasts for the western third of the country.

It was further pointed out that the day selected, September 25, was not calculated to bring out either precepts or principles of weather forecasting in the United States not already well known, and it was suggested that a day in the cold season would better serve to bring out the information that evidently was desired. The suggestion was not adopted.

U. S. Weather Bureau,
Washington, D. C.

EFFECTS OF CHANGES IN SOLAR RADIATION ON THE EARTH'S ATMOSPHERE

H. H. Clayton

The studies made by me in regard to the effects on the earth's atmosphere of changes of solar radiation as measured by the Smithsonian Astrophysical Observatory indicate that these changes have an appreciable and important influence on the earth.

In general it may be said that an increase of solar radiation causes a decrease of pressure in the equatorial regions, a rise of pressure in middle latitudes and a decrease of pressure between the 60th and 70th parallels. The increase of pressure in middle latitudes shows a seasonal change, being greatest over the continents in winter and over the oceans in summer.

A third variable which comes out distinctly is the latitude displacement of the belts of high and low pressure ordinarily found in the atmosphere. With a largely increased solar radiation (one or two per cent above normal) there is found a marked excess of pressure in high latitudes over the continents in winter and over the oceans in summer. As the solar radiation decreases, the belts of excess pressure are displaced toward the equator and with very low values of solar radiation are found between the equator and 20° N. These systematic displacements follow both short and long period changes in solar radiation. With the short period changes there is in addition a wavelike progress toward the east.

Excesses and defects in temperature and precipitation are intimately

related to the excesses and defects of pressure. With large changes of solar radiation the temperature in the center of the North American continent may change as much as 40° F.

Chief Forecaster (Retired),
Argentine Weather Service.

SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY

THE ELECTRIC CONDITION OF THE LOWER ATMOSPHERE

S. J. Mauchly

Our knowledge regarding the electrical conditions of the lower atmosphere has increased so greatly during the last two decades that it is in order to take stock, as it were, of the atmospheric-electric data now available for investigational work.

While potential-gradient records extending over a considerable number of years are available for various European stations, series of continuous observations from other parts of the globe are not only few in number but, in general, they extend over shorter periods and lack adequate control. Further, many large regions are represented solely by observations obtained at temporary field stations or in connection with special expeditions; such observations obviously serve to give only a general notion of the value of the gradient and are extremely inadequate in the matter of giving reliable indications of the daily and annual variations. Too frequently, however, the value of such data is still further diminished by the lack of adequate control observations for reducing the observational results to absolute values. Now that the general magnitude of the Earth's electric field is well known, there is less and less need for short series of uncontrolled variation observations and an ever-increasing need for extended series of well-controlled observations.

It appears unlikely that the problem of the origin of the Earth's charge can be solved on the basis of the present very general knowledge alone, and we shall need, doubtless, to know much more about the distribution and time variations of the Earth's field than can be gotten from the data now available before such solutions as may be put forth can be definitely rejected or accepted. Only the most carefully controlled observations in many representative and widely separated regions will suffice to determine whether the Earth's undisturbed field varies, let us say, with latitude, or in any other systematic way, or whether its

average value is the same the world over. Similarly, the variations during the day, year, and sunspot cycle must not only be known for more and better-distributed stations and for longer periods of time, but every source of spurious variation must be eliminated if dependable results are to be forthcoming to suggest new methods of attack and to test new theories.

When we come to matters dealing with the ionization of the air, it is, of course, realized that only the bottom of the atmospheric ocean is available to us for observation and experiment, and in our use of such data this should always be borne in mind. It remains to point out that if our generalizations regarding the Earth's field are founded on rather meager data, this is true in even greater degree as regards atmospheric ionization. Again, as in the case of the potential gradient, reliable data are exceedingly scarce. In fact, although there are at present more observatories obtaining continuous records of the atmospheric conductivity than ever before, the total number is only five, namely, two in Europe, one in North America, one in South America, and one in Australia. It may be of interest to note that the average values of the conductivity at Washington appear to differ very little from the published values for Potsdam, although different methods are used at these stations. However, preliminary values indicate that at Watheroo (Australia) the average conductivity is at least double the Washington value and that at Huancayo (Peru), at an altitude of 11,000 feet, it is five or six times the Washington value, essentially identical equipment being employed at the three stations last named. Since these observations are all accompanied by simultaneously obtained records of the potential gradient, it is obvious that much valuable information will result from a comparison of the air-earth current densities at these five widely distributed stations. Valuable as the results promise to be, however, they leave much to be desired, especially in the matter of distribution with latitude and it is hoped that other stations, especially in regions lacking such observations, will be able in the near future to supplement the observations now under way.

Investigations for determining the causes of the ionization in the atmosphere are being assiduously prosecuted by numerous observers both in Europe and America. Observations of the atmospheric conductivity and ionic density made aboard the *Carnegie* in the various oceans show that the values of these quantities at sea do not differ much from average land values, although concurrent observations aboard the *Carnegie* show that the radioactive content of sea air well removed from land is entirely inadequate to maintain the ionization there observed. Similarly, while the ionization in closed vessels has been and still is

under investigation from various points of view, the results to date afford no satisfactory answer regarding its true relation to the ionization of the air.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C.

PRESENT STATUS OF RADIO ATMOSPHERIC DISTURBANCES

L. W. Austin

Our knowledge concerning atmospheric disturbances is still very meager. In addition to the well-known relations between disturbance intensity and wave-length, time of day, season of year, etc., it is now recognized that a large number of disturbances come from definite centers, such as mountain ranges, rain areas, and thunderstorms, that a considerable portion are oscillatory in character, though some are of the nature of untuned pulses, and it is also thought that atmospheric crashes are sometimes heard simultaneously at stations thousands of miles apart.

The origin of the ordinary rumbling disturbances (grinders) has been the subject of many conjectures. Some have supposed that they might come from above and be caused by electrons shot into our atmosphere from the sun. Others have held that they can all be explained as due to the lightning in thunderstorms in various parts of the world, while still others believe that in the lightning flashes the discharge is generally too gradual to produce powerful radiation and that the atmospherics are largely due to some as yet unknown form of dark discharge which occurs not only in connection with thunder-clouds but in other air movements quite unconnected with thunderstorms. In this connection, Professor C. T. R. Wilson has shown theoretically that there may be discharges from thunder-clouds to the conducting regions of the upper atmosphere.

According to Mr. Watson Watt, radio-compass observations show that in Europe only about one-third of the atmospheric centers are connected with thunderstorms, but that about seventy-five per cent are associated with rain areas of some kind. Captain Bureau of the French Meteorological Office has collected data covering a period of many months which show a close relationship between the atmospherics in France and the advance of meteorological cold fronts.

In the United States the disturbances along the Atlantic seaboard appear to come pretty regularly from the southwest, while on the California coast the centers seem to lie among the mountains not far back

from the ocean and seem to be nearly fixed in position giving very sharp atmospheric directions. In the center of the country, observations at Madison, Wisconsin, by Professor Terry, indicate that the directions are variable, depending on thunderstorms, rain areas, etc., very much as in western Europe.

For the more convenient study of disturbance direction, Mr. Watt has designed a direction recorder which consists of a slowly rotating radio-compass coil, the shaft of which carries a drum on which a syphon recorder marks the disturbance crashes.

Mr. Watt, in collaboration with Professor Appleton, has investigated the wave form of the atmospherics, using a cathode-ray oscillograph (Braun tube). The main disturbance is found to be of audio frequency, usually aperiodic though sometimes showing slight oscillation. Some of the curves show high-frequency ripples on the main wave. These may be the real atmospherics, as it seems doubtful whether the slow-period main oscillation would be capable of producing the observed disturbing effect.

Bureau of Standards,
U. S. Department of Commerce,
Washington, D. C.

APPLICATION OF RADIO TRANSMISSION PHENOMENA TO THE PROBLEMS OF ATMOSPHERIC ELECTRICITY

J. H. Dellinger

While there is no novelty in the idea of inter-relation between the problems of radio transmission and of atmospheric electricity, nevertheless recent radio developments indicate definite hope that radio phenomena will shed considerable light on the things with which the student of atmospheric electricity concerns himself. The application of the radio phenomena to these problems is application to the underlying rather than to the immediate problems of atmospheric electricity and terrestial magnetism. Radio gives direct means of conducting controlled experiments on phenomena affected by the electrical conditions of the atmosphere, a means which is wholly impossible in the field of direct atmospheric-electric measurements. These means are being abundantly used. We are learning to select radio wave transmissions in particular directions, at particular times, and on particular frequencies, such as to produce an effect conditioned in a definite way upon electrical conditions in the atmosphere. Organization of such work is proceeding from the sporadic work of the individual to organized effort on a large scale.

After much study of the available data and consideration of possible

causes, radio science now considers that the major phenomena of radio wave transmission have their origin in the stratosphere.

While weather conditions are not entirely without effect on radio phenomena, the weather-radio phenomena are less definite and less certainly proved than the phenomena associated with atmospheric electric conditions.

Rapidly accumulating radio evidence has thoroughly established the hypothesis proposed by Eccles in 1912, which explains the greater distance of radio transmission at night by the daytime ionization of the air caused by the ultra-violet light in the sun's rays. The removal of this cause of ionization at night clears up the lower atmosphere so that the waves can penetrate to high altitudes at night. At some level in the atmosphere there must be a pressure so low that the permanent ionization above this level will render the medium conducting, thus providing something of the nature of a surface along which waves can glide at night. Turbulence near this surface explains fading. A theory definitely worked out by Larmor during the past year has more firmly established this theory by showing that the effect of the interaction of the radio wave with the ionized particles leads to a bending down of the waves, thus establishing a calculable quasi-refraction which gives a real physical picture of the wave transmission, and is a great advance over the conception of a wave sliding along a hypothetical conducting surface. This theory, with recent additions of the effect of the earth's magnetic field, enables a determination of the approximate height in the atmosphere of levels of various degrees of ionization from the observed effects of radio transmission in terms of the frequency, times of day, and other known factors of the transmission. Radio thus provides a tool with which we can actually explore these strata and determine their electrical properties.

Bureau of Standards,
U. S. Department of Commerce,
Washington, D. C.

ON THE SUPPOSED CONDUCTING LAYER IN THE ATMOSPHERE AND THE EFFECT OF THE EARTH'S MAGNETIC FIELD IN RADIOTELEGRAPHY

G. Breit

The Earth's magnetic field has been shown recently to be a probable cause of the peculiarities of radio transmission. This important discovery has been made by Nichols and Schelleng[1] as well as by Appleton

[1] *Bell System Tech. J.*, p. 215, April, 1925.

and Barnett[2] more or less as a sequel to Larmor's important paper on wave propagation.[3] The exact mathematical theory of the effect of the Earth's field is, of course, a too detailed matter to be discussed here. The fundamental principles, however, are simple. According to Larmor's theory the bending of radio waves is brought about by the presence of free ions and electrons in the upper atmosphere. The presence of these ions affects the phase velocity of the waves and makes the velocity greater at increasing heights. As a result, the wave-front turns while traveling in the upper atmosphere and bends around in such a way as to strike the ground ultimately.

This theory of Larmor's supposes that every electron or ion vibrates along the direction of the electric intensity of the incident wave. The effect of the magnetic field is to exert a force on the moving charged particle which is perpendicular to its direction of motion and to the magnetic field, and thus turns the direction of motion out of the line of the electric intensity of the wave. This results in a rotation of the plane of polarization of the wave and also in a change in its velocity of propagation. The propagation along the Earth's magnetic field is described best of all in terms of the circularly polarized waves into which one may imagine the incident wave to be analyzed. These two waves have different velocities of propagation and, therefore, are refracted differently. It is shown by Nichols and Schelleng that while one of the waves may be refracted towards the Earth the other may be refracted away from it. In other cases the two waves may be simply arriving with different intensities.

By Larmor's theorem the motion of an electron under the action of a magnetic field is the same as it would be if the magnetic field were absent and the motion were referred to a rotating frame of reference, the frequency of rotation being $\frac{e}{4\pi mc} \backsimeq 3 \times 10^6$ per second. This is seen to lie at about 100 meters wave-length. A more exact analysis shows that the critical wave-length of transmission is located at about twice this value.[4]

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[2] *Elec.*, No. 2446, p. 398, April 3, 1925.

[3] *Phil. Mag.*, 48, p. 1025, 1924.

[4] It may be shown that the differential equations $a\ddot{x} = E_x + \frac{1}{c}(\dot{y}H_z - \dot{z}H_y)$, $a\ddot{y} = E_y + \frac{1}{c}(\dot{z}H_x - \dot{x}H_z)$, and $a\ddot{z} = E_z + \frac{1}{c}(\dot{x}H_y - \dot{y}H_x)$, where $a = m/e$, which are the equations of motion of an electron of charge e, mass m, have the following solution which corresponds to the case of forced vibrations, the frequency of E_x being $\omega/2\pi$:

$$(x, y, z) = \frac{a^2\omega^2\vec{E} - \vec{h}(\vec{h}\vec{E}) + i\omega a[\vec{h}, \vec{E}]}{a\omega^2(h^2 - a^2\omega^2)}, \quad \vec{h} = \vec{H}/c$$

arrows indicating vectors and the symbols ( ) and [ ] standing for scalar and vector products, respectively. This makes the critical value of ω lie at h/a as stated (*Cf.* reference 2 and 3 above).

Both on this theory and on Larmor's one may expect the arrival at any point on the Earth's surface of two or more waves. This consequence has been investigated experimentally by Appleton and Barnett[5] who obtained evidence of waves arriving with large path differences in this way. Similarly the data of Pickard in this country offered evidence of the same nature as has been pointed out by the author.[6]

Another consequence of such a view of radio transmission must be true. It is easy to see that if the transmission takes place over two independent paths then interrupted continuous waves must arrive as two sets of interrupted waves rather than one. This effect is now being searched for at the Department of Terrestrial Magnetism with the cooperation of the Radio Corporation of America. No definite effect of the described character has been found. If this effect is absent, we may be forced to attribute more of the erratic character of radio to the effect of the Earth's magnetic field than we have been doing so far. It may be, for example, that the combined action of a partially conducting Earth and the magnetic field will give rise to complicated effects similar to interference.

Department of Terrestrial Magnetism,
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Washington, D. C.

THEORETICAL CHANGES OF THE MAGNETIC ELEMENTS WITH ALTITUDE

LOUIS A. BAUER

Confining our attention to the portion of the Earth's magnetic field—about 94 per cent for 1922—which may be expressed by a potential due to a system of magnetic and electric forces below the Earth's crust, the theoretical variation of any intensity component, C, with altitude, a, above the Earth's surface may be expressed by the following simple formula, in which terms containing higher powers of a than the first are for the present neglected:

$$\delta C_a = -3\frac{a}{R}\cdot C_o \qquad (1)$$

Here R=Earth's mean radius=6,370 kms. and C_o is the value of the particular intensity component at the Earth's surface. We may use with sufficient accuracy the approximate formula:

$$\delta C_a = -\frac{1}{2}aC_o\times 10^{-3}, \qquad (1a)$$

hence a decrease of about one two-thousandth part of C per kilometer elevation above the Earth's surface.

[5] *Nature*, March 7, p. 333–334, 1925.
[6] New York meeting of American Physical Society, February 1925.

Suppose, for illustration, that H, the horizontal intensity, is 0.2 C. G. S., and the vertical intensity, Z, is 0.55, which are the approximate values of these elements at the present time at Washington, then, if a=10 km.=about 6 miles, we have

$$\delta H = -5H_e \times 10^{-3} = -0.0010 \text{ C.G.S.}$$
$$\delta Z = -5Z_e \times 10^{-3} = -0.0027 \text{ C.G.S.}$$

These are quantities that could be detected with our present experimental means, and even for half the altitude, 5 km., or 3 miles, the expected normal decrease, ought to be readily measurable. In these measurements it would be necessary to diminish the effect of the diurnal variation, the precise changes of which with altitude are themselves the subject of investigation; by making the measurements at different hours of the day, preferably early in the morning and late in the afternoon, the effects of the diurnal variation could probably be sufficiently eliminated.

As regards the angular quantities, the magnetic declination and inclination, it may be seen readily from formula (1) that these should *theoretically* suffer no changes with altitude.

Just what the effect on the magnetic elements with height is of the other portions of the Earth's magnetic field—the external potential (about 3 per cent) and the non-potential part (also about 3 per cent)—cannot as yet be definitely stated. There are certain indications from magnetic observations made at various levels during solar eclipses and from the diurnal-variation phenomena of atmospheric electricty that there may be comparatively low-lying systems of electric forces which might play an important part in the determination of the changes in the magnetic elements even in such regions at present accessible to us by airplane or dirigible.

In general, the results from observations on mountain tops would indicate a more rapid rate of decrease in the magnetic intensity than that which formula (1a) indicates. The criticism can, of course, be made legitimately that the results from such observations may contain effects due to possible local magnetic disturbance. It is, nevertheless, gratifying to have a summary of observations made on mountain tops, such as Mr. Hazard will give in his report.

It is also of interest to note here that such observations as have been made during balloon ascents, as for example, those by James Glaisher in England in 1864, indicated a diminution in the horizontal intensity with altitude. Details with regard to the precise manner of making the observations and the rate of decrease are, however, not accessible to me at present.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C.

METHODS AND MEANS FOR THE MAGNETIC EXPLORATION OF THE UPPER ATMOSPHERE

J. P. Ault

A study of the forces which cause periodic variations or sudden disturbances in the Earth's magnetic field would be materially aided by a knowledge of how these variations are modified by changes in elevation. The magnetic exploration of the upper atmosphere has been a recognized problem for many years and its solution has become increasingly important with the rapid development of radio communication and the study of atmospheric electricity.

Theoretical considerations indicate that the changes in the absolute values of the magnetic elements with change in altitude are small. Various attempts to determine these changes have been made by observations in mountainous regions but instrumental limitations and local disturbances rendered the results unreliable.

To obtain information of any value for theoretical studies, will call for instruments of high precision because of the smallness of the changes in the magnetic elements and in their variations to be expected with changes in altitude attainable with present methods of aerial exploration. Such measurements must be controlled also by simultaneous observations at the Earth's surface.

Present instrumental equipment could be modified for use on dirigibles and would give results sufficiently accurate for practical navigational purposes. For more accurate results the most promising instrumental development would appear to be in the design of apparatus using electrical methods, with rotating coils and with galvanometers arranged for photographic registration. Such apparatus must be compact and light and suitable for mounting in unmanned carriers, such as kites or sounding balloons, by means of which much higher altitudes can be reached than by aircraft.

Some progress may be expected by observations continuing over a long period and the discussion of second differences in the magnetic variations for land stations situated not far apart but at greatly different altitudes. Such a program is planned for the near future by the Department of Terrestrial Magnetism in connection with its observatory at Huancayo, Peru, at an elevation of 11,000 feet, with temporary observatories at sea-level and an intermediate elevation. The value of such data would be greatly increased if such a program could be carried out at other points on the Earth's surface at the same time. Val-

uable information is expected also from investigations of radio communication and studies of the transmission of electromagnetic waves through the air.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C.

ALTITUDE CHANGES OF THE MAGNETIC ELEMENTS AS DEDUCED FROM OBSERVATIONS ON MOUNTAIN TOPS

DANIEL L. HAZARD

Many attempts have been made to determine the change in the Earth's magnetic field with change in altitude by observations on the Earth's surface at different altitudes, some of them more than a century ago. One of the most meritorious of these early attempts was made by Kreil in Austria about the middle of the nineteenth century. A number of others were made in Europe betwen 1891 and 1902. In June, 1918, upon the initiative of Dr. Louis A. Bauer, Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, observations were made at a number of stations in the vicinity of Pikes Peak, Colorado. The work was done jointly by the above department and the U. S. Coast and Geodetic Survey. Four stations were occupied at the top of the mountain at an altitude of 4.3 km. and there were 32 stations at lower levels from 1.7 km. to 3.7 km. The results, particularly the declination values, indicate the presence of local disturbance throughout the region.

The results of these various determinations of changes of intensity may be summarized as follows:

Authority	Locality	Year	No. of stations	Range of altitude	Proportional decrease per km.
				km.	
Kreil	Austria	1850	27	1.34	1:309
Moureaux	France	1891	4	2.25	1:326
Preston	Hawaii	1892	7	4.00	1:150
Sella	Italy	1893–4	2	4.00	1:1000
Van Rijckevorsel and Van Bemmelen	Switzerland	1895–6	?	?	?
Liznar	Austria	1898	205	1.30	1:700
Pochettino	Italy	1899	2	2.10	1:400
Do	Italy	1902	2	2.50	1:500
U. S. C. and G. S. and Dept. of T.M., C.I.W.	Colorado	1918	29	2.60	1:774

On the basis of the Gaussian potential theory Liznar found that the proportional decrease in intensity should be approximately $3h/H$ or

1:2124 per kilometer, without change of direction. Tanakadate, in connection with the magnetic survey of Japan for the epoch 1895, derived corrections for altitude from the observed changes in the horizontal plane and obtained approximately the same results as by Liznar's method. The results in the above table agree in indicating decrease in intensity with increase of height, but the rate of change is in every case several times as great as theory demands. Whether these differences are real or are to be ascribed to the effect of irregular distribution of magnetism in the mountainous regions where the necessary differences of elevation are to be found cannot be determined from the data now available, and it is doubtful whether regions can be found where observations may be made with the assurance that the results will not be vitiated by the presence of local disturbance.

[Since the foregoing was written attention has been called to observations made by W. Brückmann in Switzerland in 1909, and by A. Senouque on Mont Blanc in 1906. The former observed at 5 mountain stations and 4 valley stations in the region between Lake Thun and Lake Brienz on the north and the Rhone Valley on the south, and found a decrease of horizontal intensity with increase of height amounting to about 11γ per km., as compared with 10γ per km. to be expected on the basis of the Gaussian formulas. The northern half of the region was mainly limestone formation and apparently free from local magnetic disturbance, and every precaution was taken to ensure the accuracy of the observations, even to the extent of operating a temporary magnetic observatory at Grindelwald during the progress of the field work. Three more southerly stations were evidently somewhat disturbed and were not used in deducing the above result. In the summer of 1906 A. Senouque made observations at 6 stations on the massif of Mont Blanc at altitudes ranging from 550 m. to 4,800 m. He corrected his results for diurnal variation and for geographic position on the basis of a uniform distribution of magnetism over the region involved. He obtained the following changes with altitudes: Dip decreasing 0.5 per km.; horizontal intensity (0.213) decreasing 21γ per km.; vertical intensity (0.398) decreasing 27γ per km.; total intensity (0.452) decreasing 34γ per km. The intensity results show a consistent decrease with increase of height and Senouque was satisfied on that account that the differences were not due to local disturbance, especially as the observations were made either on the ice or on different kinds of rocks.]

U. S. Coast and Geodetic Survey,
Washington, D. C.

SECTION OF OCEANOGRAPHY

RECENT OCEANOGRAPHIC WORK CARRIED ON JOINTLY BY THE MUSEUM OF COMPARATIVE ZOOLOGY, AND BY THE U. S. BUREAU OF FISHERIES

HENRY B. BIGELOW

Since 1912, the chief field of this joint exploration, still continuing, has been the Gulf of Maine, with the coastal waters to the east and southward to Chesapeake Bay. A general survey has been made of the plankton, as well as of the physical oceanography; while the Bureau of Fisheries is prosecuting a study of the Biology of the important food fishes.

In the winter of 1914, the oceanic triangle Chesapeake Bay-Bermuda-Bahamas, and the Straits of Florida were surveyed oceanographically by the Bureau of Fisheries and the U. S. Coast and Geodetic Survey, jointly. In the winter of 1919-1920, the "Albatross" took observations along the South Atlantic coast and about Cuba.

Problems of special interest are, (1) the extent to which the temperature of the coast water is influenced by currents from the north; (2) the source of the highly saline water of the bottoms of the deeper basins on the Continental Shelf, and (3) the involuntary drifts of pelagic fish eggs and larvæ, and of the plankton.

Since 1922, the Bureau of Fisheries and the Biological Board of Canada, at the suggestion of the North American Committee on Fisheries Investigations, have put out some thousands of drift bottles, with a large percentage of recoveries.

It seems established that the Labrador current exerts only an indirect influence west or south of the Laurentian Channel.

The circulation is shown to be anti-clockwise in the large basins, clockwise around the banks.

The mixture of *banks* and oceanic water along the edge of the continent is of higher density than either of its components; hence sinks; and this so-called "slope water" is pumped into the basin of the Gulf of Maine by a rather steep density gradient.

Probably the draft of Banks water toward the zone of sinking, deflected to the right by the earth's rotation, is responsible for the southwesterly drift over the outer part of the shelf, demonstrated by many of the bottle-drifts.

Salinity, drift bottles, current measurements and the distribution of the plankton, locate the indraught into the Gulf of Maine as in its eastern, the outflow as along its western side. But the dominant drift divides off Cape Cod, part continuing to eddy eastward toward Nova

Scotia, for many bottles set out off the coast of Maine have been found along western Nova Scotia and in the Bay of Fundy.

The eddying circulation of the Gulf is shown to cause extensive involuntary migrations for most of the important food fishes, causing the fry to take to bottom far from where they were hatched.

Studies of the migrations of the cod, prosecuted by the Bureau of Fisheries during the past two years, have a direct bearing on the problems of circulation.

The work of the International Ice Patrol assumes increasing importance in American oceanography. The taking of serial temperatures and salinites, as well as a plotting of the drift-tracks of individual bergs, is a regular part of the work of the Coast Guard cutters which patrol the Grand Banks, March-July. This has greatly widened our knowledge of the interaction of the Labrador and Gulf stream currents around the Grand Banks. Lieutenant Commander E. H. Smith, who has made the oceanographic observations during the past few years, is now working them up dynamically at the Geophysical Institute in Bergen.

Harvard University,
Cambridge, Massachusetts.

THE SMITHSONIAN INSTITUTION AND OCEANOGRAPHY

AUSTIN H. CLARK

The Smithsonian Institution is the legal repository of the collections brought together by the various governmental agencies. These collections are stored in the United States National Museum. They consist of the various forms of plant and animal life and of samples of the bottom sediments.

In some cases, material resulting from a cruise has been bodily transferred to the Museum, which then becomes responsible for its study and for the preparation of reports upon it. But usually the greater part of it has been distributed, by the agency through which it was collected, to a varying number of specialists who have prepared reports upon it and returned it, after which it has been transferred to the Museum for permanent preservation.

American work in biological oceanography, so far as governmental establishments are concerned, has been chiefly a study of the various types of bottom-living animals. Our explorations have covered an enormous area in the west Atlantic and in the east, central, and north Pacific which at the time we began the work were wholly unknown regions. Naturally, therefore, the work has consisted for the most part of descriptions of the new forms of life and records of various types from different places.

These descriptions of new animals and the records of their occurrence are embodied in an enormous number of publications, mostly short, which are widely scattered throughout the various zoological journals.

At the present time there is a pause in our activities in oceanographic research so far as it concerns the bottom-living animals, and the Smithsonian Institution realizes the advisability—indeed the necessity—of taking immediate advantage of this interval of calm for collecting and correlating our present scattered and disconnected information on marine types in the form of monographic treatises each of which shall cover a broad field and, complete in itself, shall serve as a starting point for future work.

Monographic work of this type requires the undivided attention of thoroughly competent men covering long periods of time. Such men are not common and cannot be developed from the average student. They must be specially sought for and when found they must be so placed and so encouraged as to be willing to devote an appreciable part of their lives to this exacting and monotonous type of work.

The adequate publication of comprehensive monographs is a matter of very considerable expense, and at present the Smithsonian Institution cannot see its way clear to bind itself to the publication of any given piece of work of indefinite magnitude. There is a possibility, however, that the situation may become easier in the more or less near future.

For some years past the most active work in biological oceanography has had to do with those small and minute forms of life collectively known as plankton. These forms of life are of prime importance, for they include the pelagic plants of various types, especially the diatoms, through the activities of which inorganic matter is synthesized into organic, and the small animals which feed on them and in so doing reassemble the protoplasms contained in the plants into units of such size that they are available as food for larger creatures, directly or indirectly, especially for the fishes, seals and whales.

The study of plankton organisms requires a special technique varying in the different groups. Heretofore it has been localized and for the most part confined to the north Atlantic, north of latitude 42°.

The present Museum staff has been, is, and will be for some time fully occupied in the study of the vast accumulation of bottom animals which has come to it by transfer, exchange and purchase during the past forty years, and just now there are no facilities for handling plankton work.

The Institution, however, realizes the vital importance of this work on account of its bearing on the broader problems of our fisheries; and it further realizes the necessity for a broad plankton survey of the oceans as a whole.

The Museum has in storage a vast amount of material gathered by the *Albatross* and other ships and as yet unstudied, and it is hoped that the Institution or the Museum will shortly be in a position to make at least a preliminary survey of this material, as well as to get together a series of preparations of plankton organisms which shall serve as a reference collection for plankton studies.

U. S. National Museum,
Washington, D. C.

CONTRIBUTIONS TO OCEANOGRAPHY FROM THE NAVY DEPARTMENT FOR THE YEAR ELAPSED SINCE APRIL, 1924

G. W. LITTLEHALES

According to the precept of the Section of Oceanography that calls for this Report, the coast surveys executed by the Navy Department have not seemed germane to this account, and accordingly, are not embraced herein.

The completion of the continuous record of the tide at Tahiti for twelve months, by automatic gauge supplied by the Navy Department and kept under the supervision of Mr. Harrsion W. Smith, late of the Massachusetts Institute of Technology, supplements the existing resources for the study of oceanic tidal behavior in the Pacific.

During the summer and autumn of 1924, the Navy Department Conference on Oceanography laid plans, now continuing in course toward fruition, for national co-operative researches in oceanography, recommending first attention to the Caribbean and Gulf of Mexico regions and the exploration of the tract reaching to the Azores on the one hand, and to the Panama Canal and the Galapagos and Hawaiian Islands on the other.

Naval representatives in co-operation with the Bishop Museum of Honolulu have conducted the *Tanager* expedition to the northwestern islands of the Hawaiian chain and the *Whippoorwill* expedition to the islands between Hawaii and the Equator; also, in co-operation with the California Academy of Sciences, a more recent expedition in the U. S. S. *Ortolan* to the Mexican Islands of Guadalupe and Revilla Gigedo. In each of these expeditions, the collections have been chiefly in the domain of natural history.

Based upon the Bathymetric Chart of the bottom of the Pacific Ocean bordering the coast of California between San Francisco and San Diego, recently issued by the Hydrographic Office, Professor A. C. Lawson has published a discussion entitled "The Continental Shelf off

the Coast of California," Bulletin No. 44 of the National Research Council, April, 1924.

Navigators, in large numbers, without distinction of nationality, report to the Hydrographic Office concerning the phenomena of the ocean. It is from the accumulations thus gained that useful results have been put at the service of transportation and communication in such publications as the Pilot Charts of the several oceans.

Founded mainly upon the results of magnetic observations contributed by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, the Hydrographic Office has constructed and published, for the epoch 1925, world-charts of the Halleyian lines of the Variation of the Compass, the Inclination of the Magnetic Needle, and the Horizontal Intensity of the Earth's Magnetism.

The Navy is continuing to render aid to the Scripps Institution of the University of California, in a program of oceanographic observations in the Pacific Ocean. Oceanographic and meteorological observations have been made and water and plankton surface samples have been taken between San Diego and Guadalupe Island by the Destroyer fleet. Similar observations and collections are expected to be in course between San Diego and San Francisco, between San Francisco and Hawaii, between Hawaii and San Diego by that part of the Destroyer fleet that returns directly from Hawaii to San Diego, and between Hawaii and Australia by that part of the Destroyer fleet that proceeds to Australia. Before these observations were begun, all of the thermometers used in recording temperatures were calibrated.

Of the fundamental operations in oceanography, one of the most important is sounding the ocean for the purpose of ascertaining its depth and providing graphical representations of the contours of configuration of its basins. The installation of the Sonic Depth Finder in vessels of the Navy has enabled them to sound the sea in the ordinary course of voyaging.

There follows a résumé of soundings thus made during the last year:

U. S. S. STEWART, February, 1924—Line of sounding taken on run from Manila to Hong Kong. New bank discovered with least depth 146 fathoms, west of Luzon. Lat. 17° 30′ N., Long. 118° 30′ E. (approx.)

U. S. S. STEWART, March, 1924—Running survey of a specified area in the China Sea. Lines of soundings taken when searching for a number of reported dangers. Also additional soundings over the bank in Lat. 17° 30′ N., Long. 118° 30′ E.

U. S. S. STEWART, May, 1924—China Sea: Dairen to Yokohama to Shanghai to Amoy.

U. S. S. STEWART, November, 1924—China Sea: Shanghai along E. coast of Philippines to Lat. 5° 20′ N. and return to San Bernardino Strait.

U. S. S. MILWAUKEE, March, 1924—North and Central America and Mexico.

U. S. S. MILWAUKEE, October, 1924—En route Transatlantic flight ZR-3, N. Atlantic: Soundings taken off the east coast of the U. S. in the North Atlantic Ocean; in the West Indies; off north coast of Cuba.

U. S. S. MILWAUKEE, September, 1924—N. Atlantic—Davis Strait, west coast of Greenland.

U. S. S. CONCORD, February, 1924—Indian and North and South Atlantic Oceans; Port Sudan to Djibouti and Djibouti to Barbera; Barbera to Mombasa to Zanzibar; Lourenco Marques to Durban; Durban to Port Elizabeth; Port Elizabeth to Cape Town; Cape Town to Walfisch Bay; Walfisch Bay to St. Helena.

U. S. S. CONCORD, March, 1924—St. Helena to Pernambuco; Pernambuco to St. Thomas, thence to Vieques Sound.

U. S. S. COLORADO, February, 1924—North Atlantic Ocean—Gibraltar to New York. Colorado Bank discovered in 33° N. 37° ½ W.

U. S. S. CINCINNATI, March, 1924—North Pacific Ocean—off west coast of Mexico near Cape Corrientes.

U. S. S. NIAGARA, December, 1924—Caribbean Sea—La Guaira, Venezuela, and Willemstadt, Curacao, to Gulf of Venezuela.

U. S. S. RALEIGH, October, 1924—North Atlantic—vicinity of Faroe and Iceland.

U. S. S. MARYLAND, March, 1924—North Atlantic Ocean—off coasts of Maryland, Virginia, and North Carolina.

U. S. S. MARYLAND, December, 1924—North Pacific Ocean; off the coast of California in vicinity of San Diego. Unsuccessful search for bank of 50-90 fathoms in 32° 65′ N., Long. 119° 45′ W.

U. S. S. HULL AND CORRY, May, 1924—North Pacific Ocean; soundings taken to discover practical route for cable to be laid between Seattle and Alaska.

U. S. S. CORRY, October, 1924—N. Pacific Ocean; Cape Descanso to Santa Rosa Is. and between San Francisco and Monterey Bay.

U. S. S. HANNIBAL, December, 1924—North Atlantic; Delaware Breakwater to Hampton Roads and from latter place to Key West.

U. S. S. HANNIBAL—North Atlantic, West Indies; Key West to Siguanea Bay, Isle of Pines.

U. S. S. MARBLEHEAD, January, 1925—Southampton to Marseilles, to Algiers; Funchal to Boston.

U. S. S. HULL, February, 1925—Development of Santa Rosa Bank, California.

U. S. Hydrographic Office,
Washington, D. C.

PHASES OF WORK OF THE CARNEGIE INSTITUTION OF WASHINGTON WHICH CONCERN THE SECTION OF OCEANOGRAPHY

J. P. Ault

That part of the work of the Carnegie Institution of Washington during the past year which is of special interest to the Section of Oceanography was the continuation of the studies in marine biology at the Tortugas Laboratory, Florida, and the interest in deep-sea sounding stimulated by the activities of the Advisory Committee in Seismology of the Institution, already reported by Dr. Littlehales.

During the summer of 1924, ten research workers were present at the Tortugas Laboratory carrying on investigations more or less relating to the biological phase of oceanography, and material was collected for study in connection with the problem of the formation of marine limestones. This station is to be maintained, and important contributions to marine biology are confidently expected from future researches.

The ocean-survey work of the Institution's Department of Terrestrial Magnetism has not been resumed since the completion of the sixth cruise of the *Carnegie* in November, 1921. It is hoped this work may be taken up again soon, the plans calling for a three-year cruise in all the oceans, followed after an interval of three years by a second three-year cruise. This program, if carried out, will greatly enhance the practical and theoretical value of the ocean magnetic and electric work already done, in supplying much-needed secular variation data, and will furnish opportunity to undertake additional investigations having a more direct bearing on oceanography. The intensive program of magnetic work heretofore undertaken will be materially reduced, thus giving time for more work in atmospheric electricity, earth-currents, gravity, radio communication, and deep-sea sounding. A new sonic sounding apparatus, devised by Dr. H. C. Hayes, will be installed, and a systematic and complete series of soundings over the routes to be covered during the proposed cruises, as shown on the accompanying chart, will add much information to our knowedge of the contour and topography of the oceanic basins and will be extremely useful in the study of other oceanographic problems.

Since previous cruises were arranged more with a view to increasing our knowledge of the distribution of the magnetic elements over the oceans, only eighty intersection points were established from which data regarding the secular variation in magnetism may be obtained for all the oceans. The recent discussion by Mr. H. W. Fisk[1] of secular variation

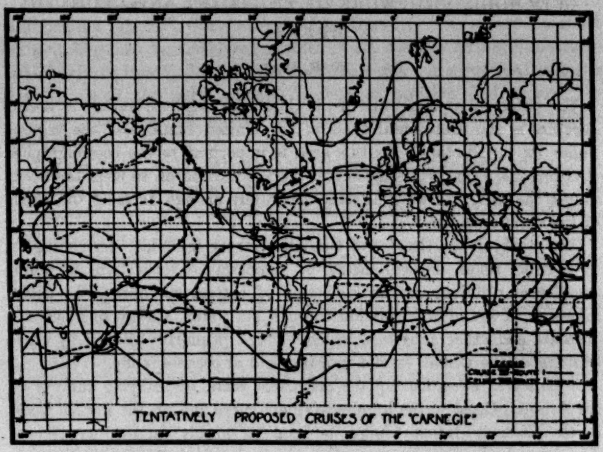
[1] *Terr. Mag.*, vol. 29, No. 4, p. 139-148, December, 1924.

over land areas, particularly over South America and Africa, has shown the need of additional control from observations at sea. Especially did the discussion show the desirability of knowing the variations over short periods of time. Accordingly, future ocean work is planned to yield the maximum information possible regarding secular variation, and the routes will follow closely the tracks of previous cruises.

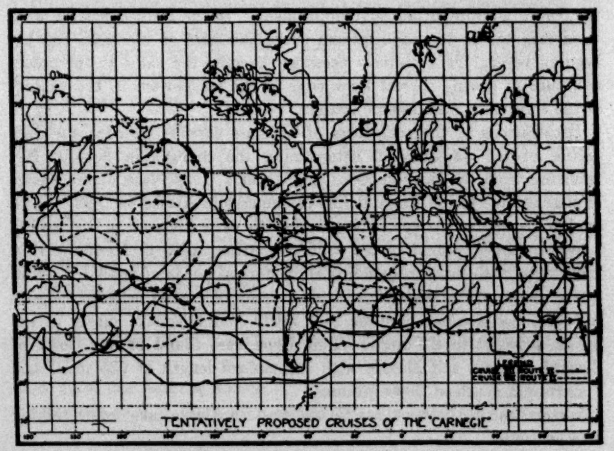
The rapid development of radio communication and the study of the transmission of electromagnetic waves around the earth emphasize the need of increasing our knowledge of atmospheric electricity and its variations over the oceans and show the desirability of studying at sea the daily and seasonal effects on the intensity and directional conditions of radio transmission and reception. The researches of Appleton and Barnett of Cambridge and of Nichols and Schelleng of the Bell Telephone Laboratories in this field, as reported in *Nature* of March 7, 1925, show the importance of knowing the atmospheric-electric variations at sea as well as over land. Appleton and Barnett attribute the variation between day and night strengths of signals to ionization due to solar agencies, hence to atmospheric-electric variations, while Nichols and Schelleng state that "the theory (of propagation of radio waves over the earth's surface) now developed takes into account both the earth's magnetic field and the distribution of ionized particles in the atmosphere."

In connection with the Department's study of earth-currents at the Watheroo and Huancayo observatories, it is planned also to make some observations on earth-currents at sea during future ocean work, in an attempt to determine how such currents are modified over the oceans as compared with those occurring over land areas.

It is hoped that some form of gravity apparatus will be developed which will give reliable results at sea so that the determination of the gravity anomalies over the ocean areas may be included in the work of the proposed cruises of the *Carnegie*.



CRUISES TO START FROM WASHINGTON IN DECEMBER



CRUISES TO START FROM WASHINGTON IN JUNE

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C.

OCEANOGRAPHIC WORK OF THE COAST AND GEODETIC SURVEY

N. H. Heck

The principal area of work of the Coast and Geodetic Survey in oceanography is the continental shelf of the United States and the regions under its jurisdiction. As this area is important to the oceanographer it is fortunate that while the survey work is carried on to meet the needs of the mariner, the work is done accurately enough to meet the needs of the oceanographer.

The work of the Coast and Geodetic Survey includes: determination of bottom relief, measurements of temperature, collection of water samples at different depths, collection of bottom specimens, the determination of sound transmission through sea water, studies of tides and currents and other activities, which, though primarily covered by other Sections of the Union, extend into the field of oceanography.

A policy in effect during the last three years, of carrying surveys on the Atlantic Coast to the hundred-fathom curve and on the Pacific Coast to the thousand-fathom curve, is bringing highly satisfactory results. The important progress, especially in southeastern Alaska, was shown by means of a chart. In the West Indies a survey of the Nares deep by the *Guide* is an important accomplishment. In the Philippines the work is carried to the thousand-fathom curve and half of the Sulu Sea has been surveyed. It is scarcely necessary to state the value to the oceanographer of having correct knowledge of the sea bottom in the vicinity of the continents and oceanic islands.

Illustrations of the usefulness of accurate surveys include: the difficulties of the Japanese in determining the changes in Sagami Bay resulting from the earthquake of September 1, 1923; lack of knowledge of changes due to the Yakutat Bay earthquake in Alaska in 1899. With modern accurate surveys, changes due to earthquakes can be readily detected. Development of the wide submarine valley in Monterey Bay, California, with no corresponding shore formation, is of special interest.

The cruise of the *Guide* completed a series of cruises between the east and west coasts which resulted in a fairly comprehensive survey of the region adjacent to the route. Two deeps were found off the Coast of Central America and Mexico with a combined length of 625 miles and a maximum depth of 3600 fathoms.

Vessels cruising between Seattle and western Alaska take oceanographic data en route.

Steady progress has been made in the use of acoustic methods for sounding and position finding on the coast of Oregon and Southern California.

British studies of the velocities of sound check with those given in Publication No. 108, Coast and Geodetic Survey. The acoustic method of sounding may be considered as established, but has certain limitations which will be clearly defined with continued use. A great deal is being learned about the radio acoustic method of position finding and the transmission of sound waves. Maximum distance obtained is eighty-five miles.

Temperatures, water samples and bottom specimens were obtained in each locality in a manner which involves little additional cost to the government. Scripps Institution determines the salinity and examines bottom samples.

With reference to tides, attention is called to the following publications:

Harmonic Analysis and Prediction of Tides, by Paul Schureman; a treatise for the tidal mathematician.

Portable Automatic Tide Gauge, by G. T. Rude (in press). This describes an apparatus which obtains tidal data more economically than heretofore.

The Tides, by H. A. Marmer, (about to go to press); a non-mathematical discussion valuable to the non-tidal oceanographer.

Mean sea level is being studied.

Observations by Dr. Meinesz of the Dutch Geodetic Commission, for determining gravity at sea, made on a submarine, have been reduced by the Coast Survey method. The portion of the Indian Ocean so far studied is in a very nearly perfect state of equilibrium. Work is to continue between Holland and Java by the Panama Canal. A one hundred dollar grant from the Philosophical Society of Washington is going to make possible the isostatic reduction of gravity stations on some islands in the Pacific. The establishment of the physical fact of equilibrium will be of great value in the study of configuration of the ocean beds and the processes which operate to change their elevations.

No magnetic work is being carried on at sea, as that of the *Carnegie* is so superior to that of a magnetic vessel. It is hoped her work can be resumed in the near future.

The *Los Angeles* now carries a ship's type dip-circle of the Coast and Geodetic Survey to study the possibility of magnetic observations in the air.

U. S. Coast and Geodetic Survey,
Washington, D. C.

SECTION OF VOLCANOLOGY

SUMMARY OF REPORTS OF COMMITTEES

R. B. SOSMAN, *Secretary*

The Secretary reported for the Committee on the Igneous Geology of Yellowstone Park (Cross, Daily and Van Orstrand). Mr. Cross had made an examination of the manuscript left by Arnold Hague intended to be published as Volume I of the Monograph on the Park. He has found the manuscript in much less advanced stage of preparation than has been supposed. It would appear that considerable revision and additional work may be necessary in order to complete the petrographic data. Mr. Van Orstrand has examined the data on spring temperatures and thought that much of this could be prepared for publication. The material consists of about eighty packages of manuscript with many specimens. The report of the Committee was supplemented by Mr. Day who said that some new work on the Hot Springs was being planned by Mr. Allen and himself on behalf of the Geophysical Laboratory. Mr. Jaggar said that he had been an assistant to Hague in the field and that Hague had followed closely Archibald Geikie in his style of presentation and treatment of the subject matter.

Mr. Mendenhall of the Geological Survey stated that Prof. Setchell's chapter on Algae had been released to him for publication if he so desired and that the Hot Spring data, or any other data considered useful, would either be released for the use of the Geophysical Laboratory or would be incorporated with the new work of the Laboratory in some form of publication by the Survey.

The Committee on an International Catalog on Volcanoes had no report. Mr. Jaggar stated that Sapper's catalog had been published in the Zeitschrift für Vulkanologie and also in the Proceedings of the Strasbourg Society.

The Committee on Hot Springs (R. B. Sosman and Kirk Bryan) reported that the 1923 symposium on Hot Springs had been published. There had also been discussion with members of the Weather Bureau concerning the possibility of correlating variations of Hot Spring temperatures with rainfall and air temperature. Some manuscript data on western springs had been obtained from the Weather Bureau. Mr. H. T. Stearns supplemented this report by statement that Miss N. E. Dowell's bibliography of Hot Springs in the United States was being mimeographed and was to be distributed for corrections and additions.

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